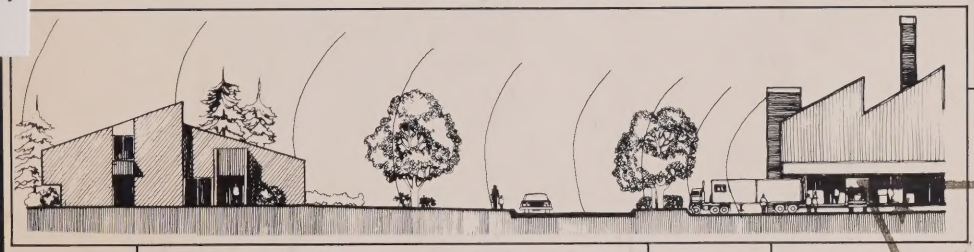
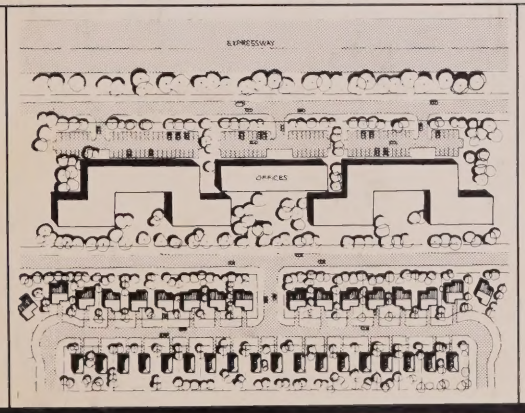
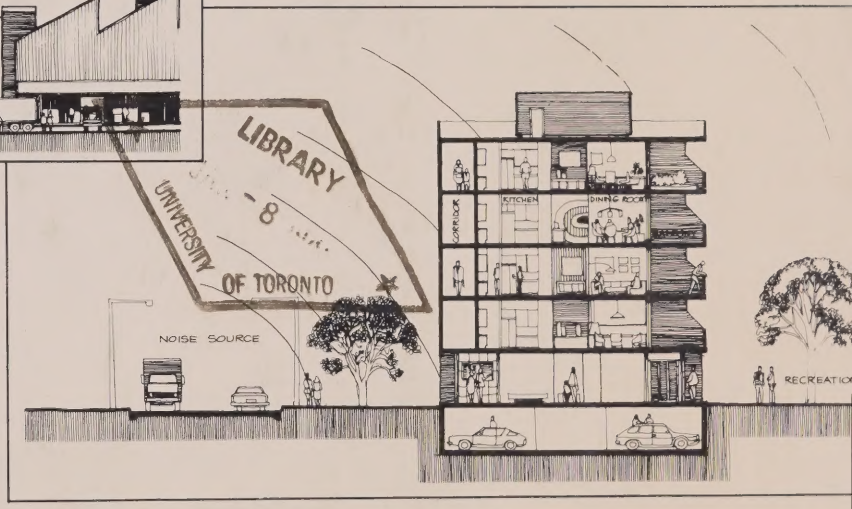
Land Use Planning for Noise Control in Residential Communities







August 1980

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LAND USE PLANNING FOR NOISE CONTROL IN RESIDENTIAL COMMUNITIES

Ontario
Ministry of
Housing

LAND USE PLANNING FOR NOISE CONTROL IN RESIDENTIAL COMMUNITIES

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Preface

Noise in residential areas has become of greater concern in recent years. It is now expected that housing developments be designed to protect the residential environment as much as possible from external noise.

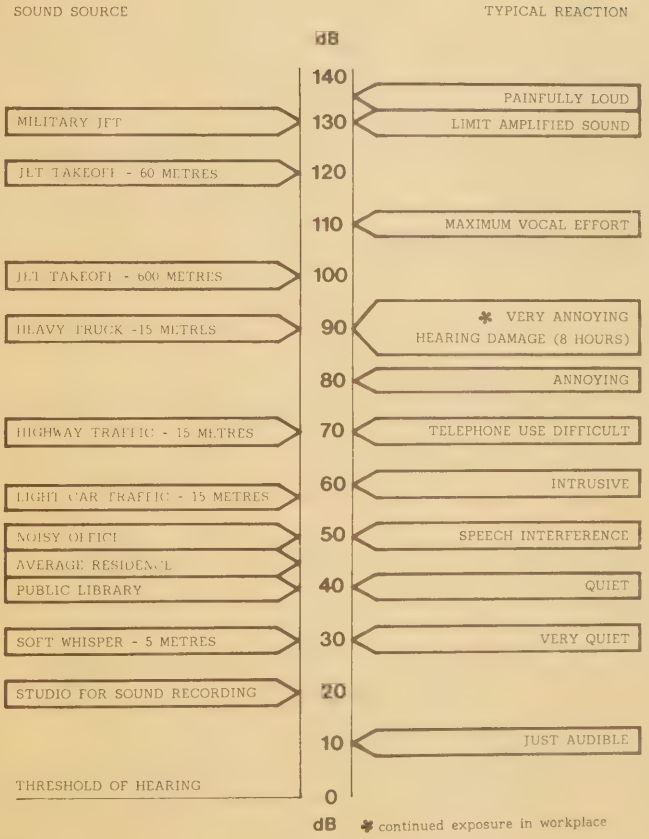
The purpose of this report is to encourage municipalities and developers to use *land use planning* as a noise control measure in order to minimize the chances of creating noise problem areas. Put simply, it means a proper place for every land use so that each use is compatible with the surroundings. The overall goal should be to reduce the amount of residential land adversely affected by noise.

Municipalities, planners, developers, builders, engineers and other groups directly involved in the planning, development and approval of residential development were consulted in the preparation of this report. As always, these consultations were very beneficial and resulted in a number of significant changes to the document.

G.K. Bain
Director
Local Planning Policy Branch

August, 1980

1.1 Common Noise Levels and Typical Reactions



1. Introduction

The control of noise through Land Use Planning in residential areas is the subject of this report. It is intended to help municipalities better evaluate and implement Land Use Planning Measures that will control noise in residential areas.

Only recently has noise been considered a factor in planning our communities. Concern over noise has developed because of the increase in levels of community noise and the amount of land affected by such noise.

The effects of noise

The effects of noise are numerous. Both physiological and psychological effects of human exposure to high noise levels have been identified. Individuals exposed to excess noise are likely to first experience annoyance, sleep interference, and interrruption of activities, such as conversation, reading, listening to the radio and watching television.

The first step involved in effectively dealing with a noise problem involves the identification and description of the noise problem. Section 2 of this report indicates that every noise situation is unique although there are certain sources of noise such as roadways, railways, and airports which are major contributors to community noise. Section 2 also provides information related to prediction techniques which help to define the extent of a given noise problem.

Determining the extent of the noise problem involves comparison of a given noise to acceptable sound level limits. The Province has developed acceptable sound

Noise control measures currently in effect

level limits for residential development affected by noise from airports and freeways. This information is reproduced in Appendix 6.2. In addition to these standards the Ministry of the Environment has developed guidelines related to community noise in general. Each municipality may, after consideration of these guidelines, establish acceptable sound level limits for community noise in their municipality.

The solutions to a noise problem

There are three potential solutions to a noise problem which have been defined. The noise source may be controlled; the path of the noise may be blocked by some barrier; or it may be possible to separate the noise source from land uses sensitive to noise. As the abatement or control of noise at the source is not a municipal responsibility, this report deals with measures that intercept the path of the noise or separate the noise source from the receiver. Specifically, this report deals with Land Use Planning as a noise control measure. In Section 3, Land Use Planning measures to control noise are discussed under the sub-headings of Official Plans, Secondary Plans and Plans of Subdivision.

Land use planning to control noise

This report emphasizes the use of Land Use Planning techniques to control noise because it is believed that such solutions are: a) cost effective; b) acceptable to the general public (and therefore marketable); c) have the potential to alleviate future land use/noise conflicts; and d) have the potential to minimize various costs if implemented early in the planning process.

To a large extent this report deals with the current "State-of-the-Art" in noise control through Land Use Planning. It proposes no solutions which have not been tried and proven successful. It emphasizes Land Use Planning solutions to noise problems in new residential areas. Through Land Use Planning, communities can be designed so as to minimize the effects of noise on residential areas. In developed areas, there may be better or more suitable solutions such as acoustic barriers, building design and construction techniques. (Section 4 of this report briefly discusses such measures.)

Concern about noise is sufficient for this report to have been prepared. It should be understood, however, that such concern is only one factor in a comprehensive land use planning process.

2. Typical Noise Exposure

Each noise situation is unique

There exists a wide range of noises to which individuals are exposed in their day to day lives. As can be imagined, every road or railway generates different levels of noise. Similarly, each industrial use and airport produces varied levels of noise. It is not possible to specifically identify all the situations which may occur; however, by considering some of the following examples of typical situations one should be able to apply the principles illustrated to specific cases.

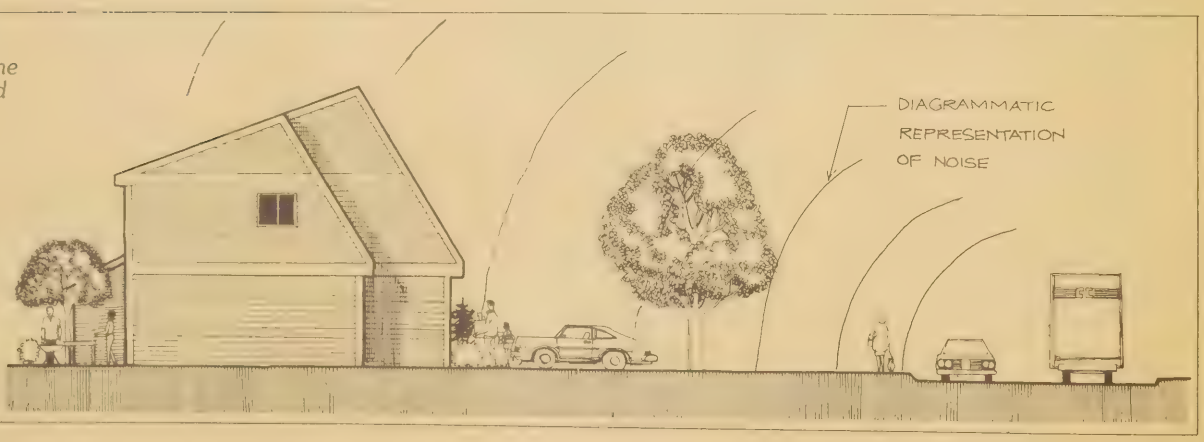
Roadways

Direct measurement or prediction models

Where a freeway, arterial, major road or street is in close proximity to a proposed residential development, there will be the potential for a noise problem. The extent of that problem may be determined by direct measurements with a sound level meter or as a result of applying a noise prediction model.

2.1 Roadway Noise

Noise levels depend on the number, speed and mix of cars and trucks; the type, elevation, gradient, surface and distance of the road.



The former technique limits itself in that it may be difficult to isolate the noise from a given source in a noisy environment. Alternatively, the prediction of noise levels through empirically based noise models allows for predictions of the future noise levels which might anticipate such factors as increased traffic volume. (In planning for noise mitigation in residential areas it is necessary to consider traffic volumes and consequent noise levels over a minimum period of 10 years into the future).

The variables of roadway noise

Factors to be regarded in evaluating roadways as a noise source include:

a) distance from edge of roadway to receiver;

b) elevation of receiver relative to the noise source;

c) hourly volume of cars;

d) hourly volume of trucks;

e) average operating speed of vehicles;

f) pavement gradient;

g) pavement surface texture; and

h) future traffic volumes.

Railways

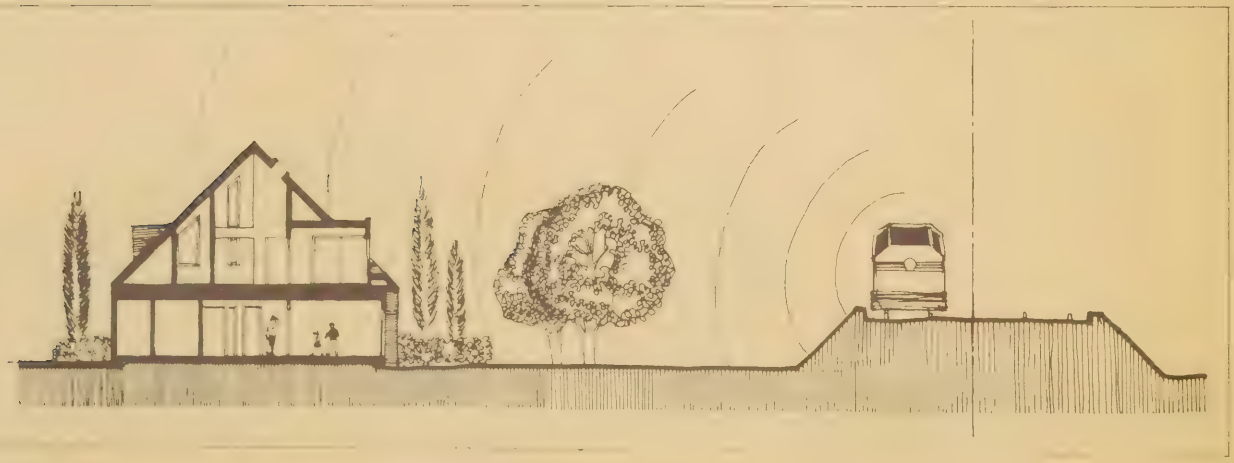
All rail lines in close proximity to the proposed development must be considered in order to determine the noise impact on a given site.

In determing noise levels generated from a railway line, it is most appropriate to make use of a noise model developed for the purpose. Factors, among others, which may be included in such a model are:

The variables of railway noise

a) distance from rail line to receiver;
b) elevation of rail line;
c) the time of day which trains pass the point in question;
d) the type of train (e.g. passenger, freight or switcher);
e) the average number of locomotives;
f) the presence of special operating procedures such as accelerating or decelerating trains;
g) the number of whistle points within 1 kilometer (½ mile) of the site;
h) the possibility of increased train traffic;
i) bolted or welded rail sections;
j) train speed; and
k) track gradient.

2.2 Railway Noise



Airports

Airport noise is different

Airports pose a different noise problem than that generated from road and rail traffic. The problem differs because of the frequency of the sound created by aircraft, and because of the two fold nature of the problem, aircraft flying over a site as well as landing and take-off. The severity of the problem is best described by the Noise Exposure Forecast (NEF) contours which are available for most commercial and military airports.

These contours are developed after careful consideration of air traffic characteristics which include types of planes and frequency of landings and take-offs.

Industries and Commercial Activities

The variables of industrial noise

The following factors will be of importance in determining the impact of noise on proposed residential development:

a) distance between industry/commercial activity and receiver;

2.3 Industrial Noise

Noise levels vary considerably dependent on the type of industry; the structure, truck access and loading, and distance from residences.

b) hours during which industry/commercial activity operates;

c) nature of noise source (constant, infrequent, impulsive, explosive); and

d) associated traffic noise.

Other Less Common Noise Sources

Other less common noise sources exist which would require specialized assistance in order to determine their impact and possible mitigation measures. Such noise sources may include:

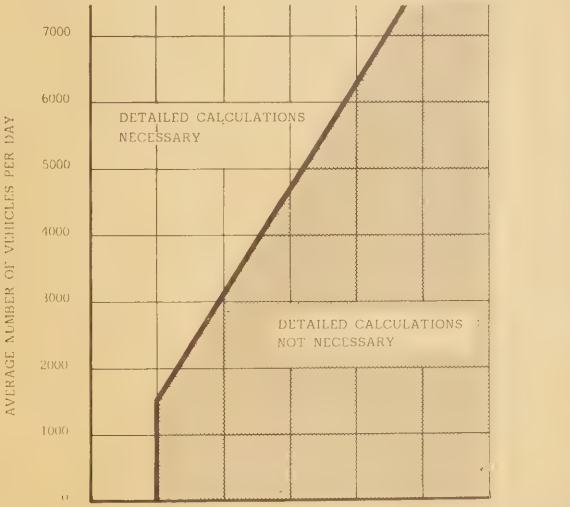
-quarries,
-land fill sites,
-electric transformers,
-amusement parks, and,
-sand and gravel pits.

Because of the diversity of such noise generators it is not possible to enumerate those factors that must be considered in determining the impact of noise on a residential area. Each situation will require the advice of noise consultants.

Vibration

Situations exist where the noise problem manifests itself in the form of vibration. This vibration may or may not produce audible sounds but may pose problems similar to the annoyance factor associated with high noise levels. It is beyond the scope of this report to deal with problems related to vibration, although some of the noise mitigation measures mentioned in the following section may be effective in the mitigation of vibration.

2.4 Need for Detailed Calculations



NOTE: This chart applies for speeds of 50 k.p.h. (30 m.p.h.) or less, and negligible truck traffic.

Need to Define Problem

The intent of Section 2 of this report has been to identify the generators of community noise. Because of the unique characteristics of each situation it is virtually impossible to define the extent of each and every noise problem within one report.

Need for a noise study

Before any noise mitigation measures can be considered it is essential to know where a noise problem exists, or is likely to exist, and the extent and nature of that problem. Although some tables exist (See Figure 2.4) to assist in the decision as to whether a noise study is or is not required, most situations will require the advice of an acoustics engineer and possibly the completion of a noise study. (The suggested format for a noise study is included in Appendix 6.3). Such a study should detail the extent to which the noise problem exceeds acceptable sound level limits (See Appendix 6.2) and may suggest alternate solutions for mitigating the noise.

Defining the extent of a noise problem is the first step in lessening the effects of noise on residential development.

Noise control by-law

In some cases it may be possible to regulate the source of the noise. The Noise Control By-Law which a municipality may adopt under *The Municipal Act* or *The Environmental Protection Act*, is an important means by which a municipality can control noise pollution. However, it is not usually possible for a land use planner or a municipal official to control the amount of noise produced by any particular noise source. The noise levels produced by a truck or locomotive engine are questions which can only be dealt with by the manufacturer and the federal government, which set standards for such products. It is the purpose of this report to describe the mechanisms available to the local municipality to control noise through Land Use Planning. In addition to these Land Use Planning noise control

measures there are other measures with which local municipalities may become involved. All these Noise Control Measures are discussed in Sections 3 and 4 of this report.

3. Noise Control Through Land Use Planning

Land Use Planning could be described as the art of arranging land uses in a compatible manner. In considering noise in the planning of an area, it makes sense to distribute land use so that uses generating noise are located so as not to interfere with 'quiet' uses such as residential areas.

Planning must be comprehensive

It is the purpose of this report to emphasize information related to noise control through Land Use Planning. It is most important to comprehensively plan any given site and to be aware of all the influences involved. It is necessary to place in perspective the fact that noise mitigation, although important, may be of no greater consideration than say the achievement of municipal housing and energy conservation objectives. (Appendix 6.5.2 lists publications that deal with Land Use Planning in general).

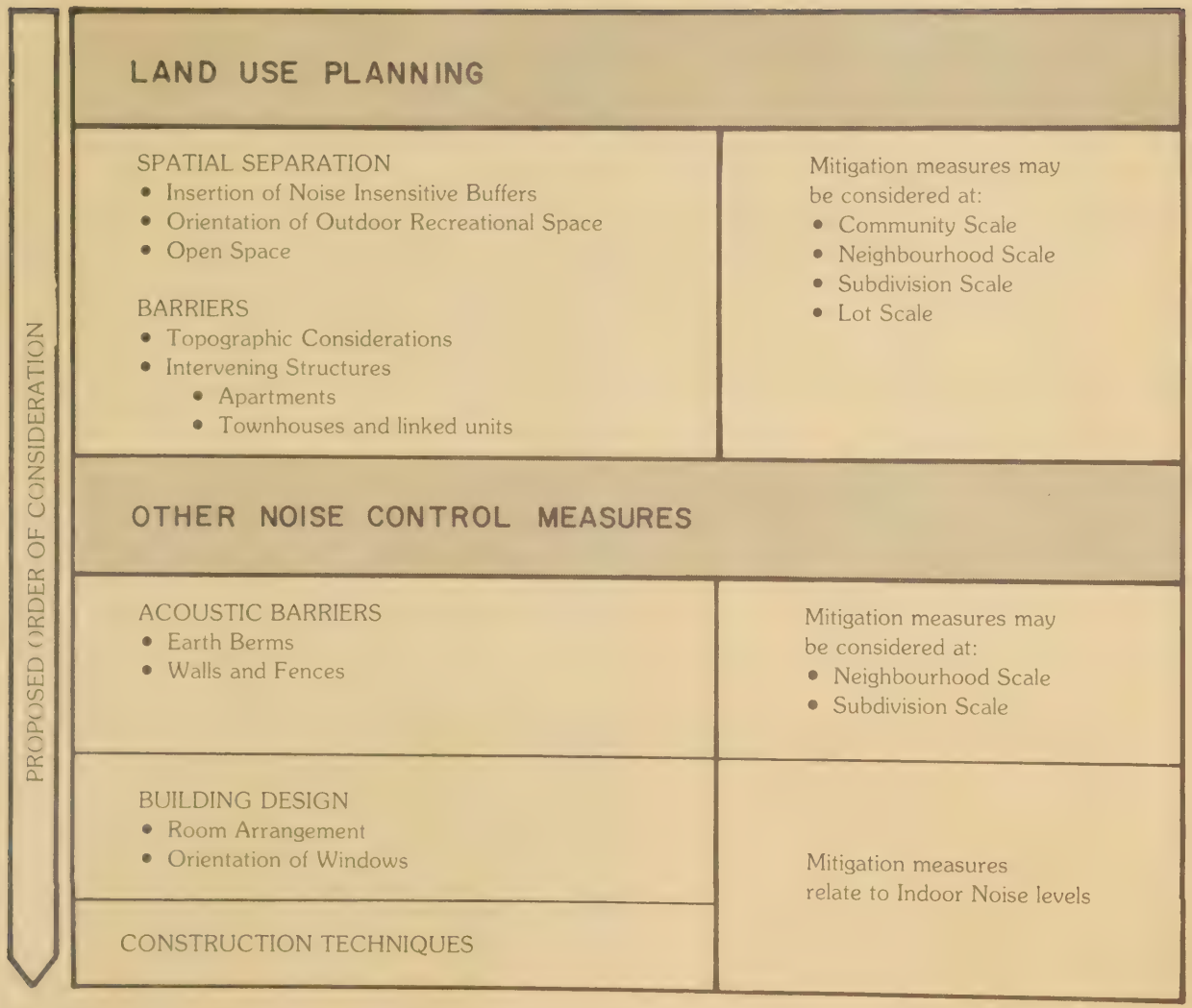
Consider noise when planning begins

In considering any new development or redevelopment of existing buildings, it is important to begin dealing with noise as an issue at the early stages of design. If there is a noise problem, it can often be resolved with minimum expense if it is taken into account in the overall planning and design of the development from the start.

Figure 3.1, Noise Control Measures, lists specific noise mitigation measures under the headings of Land Use Planning and Other Noise Control Measures. Although there are other ways in which these measures could be grouped, they have been listed in the order in which they should be considered in the Planning Process.

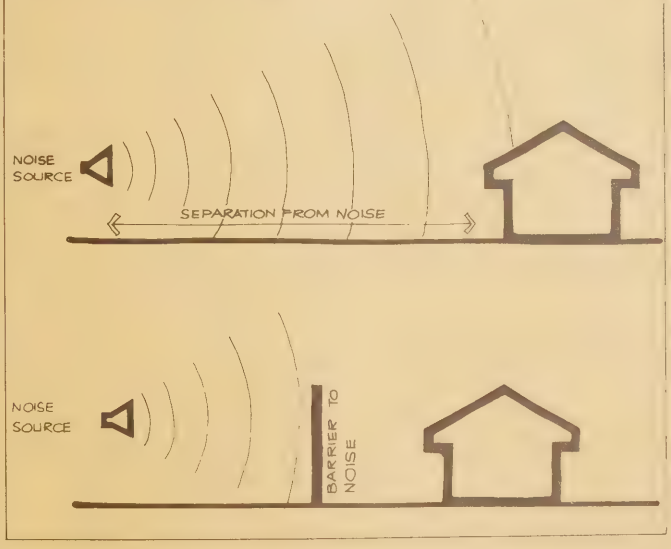
The following text describes the noise control measures shown in Figure 3.1, under separate subsections of this report. It should be understood, however, that in considering a given situation the most appropriate solution may be a combination of several measures.

3.1 Noise Control Measures



3.2 Principles of Noise Mitigation

Noise mitigation measures can be categorized as either utilizing distance or introducing a barrier, to reduce noise levels. Usually measures combine both principles.



Indoor and outdoor noise controls

It is necessary to consider both the noise levels inside a dwelling and those levels likely to occur in the outdoor recreation space associated with each unit. In general it can be said that Building Design and Construction Techniques deal with the reduction of noise inside a dwelling. Land Use Planning and Acoustic Barriers may be used to reduce noise levels outside and may also result in noise reductions inside.

Two principles of noise mitigation: separation or barriers

It is possible to think of the noise control measures listed in Figure 3.1 as being based on one of two principles. The noise mitigation measures work either through SPATIAL SEPARATION (to separate the noise source from the receiver) or by means of a BARRIER (between the noise source and the receiver).

Planning occurs at different scales

There are various scales at which a Municipality may become involved in Land Use Planning. Through Official Plans and Secondary Plans the arrangement of land uses within the community or a given neighbourhood may be established. Through the zoning, subdivision approval and site plan approval process noise mitigation measures may be effected at the subdivision and residential lot level.

Legislative framework for noise control

The Planning Act provides the framework in which noise control measures can be implemented in the Land Use Planning Process at all scales.

Under *The Planning Act*, municipalities are authorized to produce Official Plans which provide general statements on the goals and objectives of the municipality. The municipality is also authorized to produce a Zoning By-law which provides a legally enforceable interpretation of the Official Plan goals. It is through these two documents (together with the municipality's involvement in the subdivision and site plan process) that a municipality is enabled under *The Planning Act* to have regard for the environment in which its citizens live.

The remaining parts of this Section of the report will examine the way in which Official Plans, Secondary Plans and Plans of Subdivision can be used to bring about noise control through Land Use Planning.

Official Plans

By means of the Official Plan a municipality is able to provide a guide for future development and to indicate the location of services and facilities within a desired development pattern. In determining the development pattern for the municipality, criteria such as the following will be evaluated:

- availability of municipal services such as sewer and water lines;
- natural features such as hazard lands and flood plains;
- projection of future economic and population growth; and
- health and welfare objectives concerning such matters as *noise*, air and water pollution.

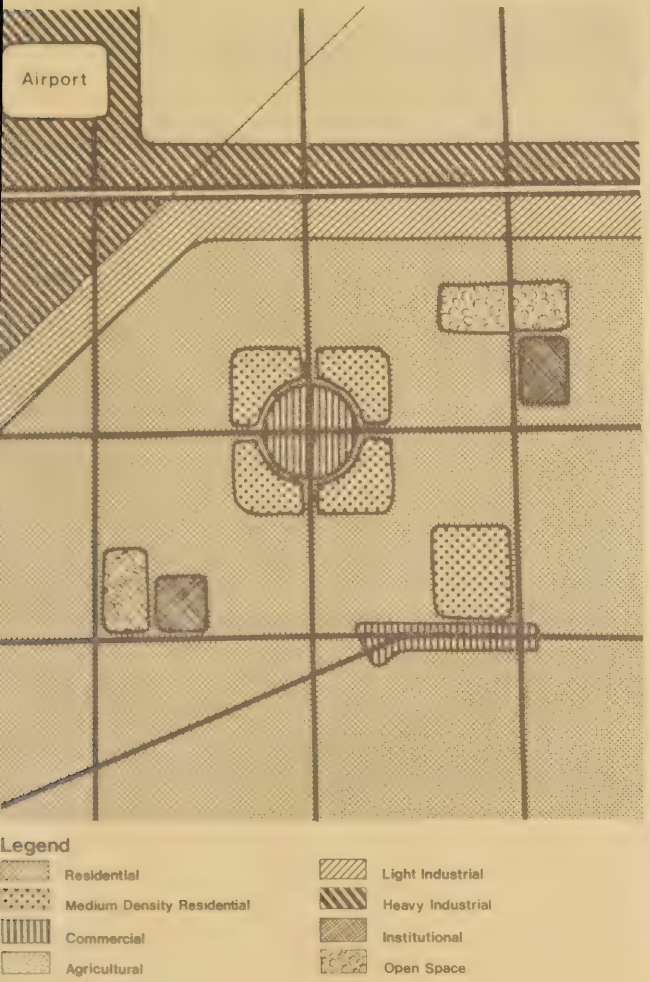
Noise is only one factor which should be considered in the development of an Official Plan.

Noise policies in Official Plan

Official Plans should include statements related to noise pollution. It is important for the municipality to consider the possible impact of noise and necessary abatement measures during the preparation of its Official Plan and Secondary Plans. Some very effective noise mitigation measures (such as the arrangement of land uses and spatial separation) must be considered at an early stage in the planning process. Further, the incorporation of noise policies within the Official Plan will ensure a comprehensive, rather than a piece-meal approach to noise problems.

.3 Typical Official Plan Land Use Schedule

The airport, rail line and major highway are surrounded by industrial uses. Light industry separates these land uses from residential areas.



Official Plan Policies

The Official Plan should provide two types of noise related policies. These include:

a) receiver-oriented policies aimed at protecting new residential developments against the impact of noise created by existing sources or new sources of noise that may be established in the future; and

b) source-oriented policies aimed at controlling noise due to new potential sources of noise including transportation systems, industrial operations, commercial operations, and other sources such as quarrying and mineral extraction.

The Official Plan should address the following sources of noise:

a) major roadways including freeways, highways and major arterial roads;

b) aircraft noise due to operation by airports;

c) railway noise created by such occurrences as train passby, marshalling yards, piggy back terminals and siding yards;

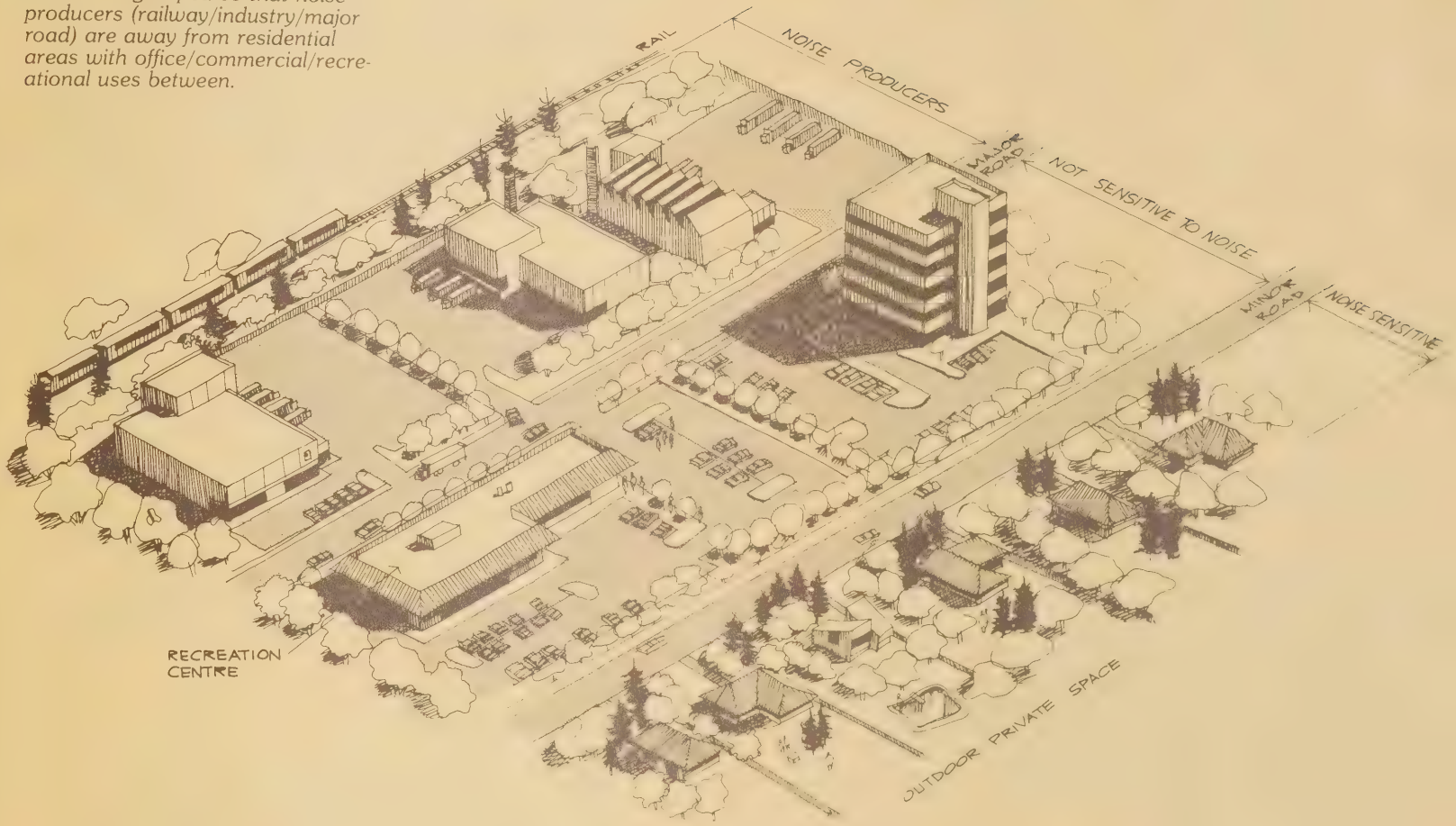
d) industrial sources of noise including the noise created by outdoor installations as well as housed industrial operations;

e) commercial sources of noise; and

f) quarries and mineral extraction operations.

3.4 Land Use Planning: Neighbourhood Scale

Land uses grouped so that noise producers (railway/industry/major road) are away from residential areas with office/commercial/recreational uses between.



The Official Plan should regard the noise outdoors and the noise indoors as being of equal importance. The inclusion of objective sound levels or quantitative criteria is optional, depending on the extent to which the municipality is willing to accept detailed information.

Noise contours can be included

The Official Plan could show simple noise contours such as Leq levels, in particular for linear sources of noise such as freeways and major arteries. NEF contours due to aircraft operation should form part of the plan and may be included in the appendices or as a schedule to the plan.

Official Plan Land Use Schedules

In addition to the policy statements of an Official Plan, careful consideration should be given to the distribution of land uses at the community scale in formulating the land use schedule. For example, the noise problems associated with a commercial or military airport must be taken into account. Similarly, the location of a major freeway will affect the proposed distribution of land use within the community. In these examples, of an airport and freeway, special studies would indicate the required separation between the noise generator and proposed residential development. Such a study would also suggest land uses which may be located, without harmful effect, between the proposed residential development and the noise generator. Such uses may include offices and industry.

Secondary Plans

In many municipalities Secondary Plans form part of the Official Plan process. These Secondary Plans are often intended to provide a more detailed concept of land use distribution at the Neighbourhood or District Scale.

3.5 Typical Secondary Plan Land Use Schedule

Industry is used to separate the residential areas from the major highway.

Within a Neighbourhood there may be significant natural topographic barriers that can mitigate noise generated from a freeway or railway. Similarly, the possibility may exist for a barrier or intervening structure (such as apartments and linked units) to shield the remaining land in a neighbourhood from noise.

However, the principal method of noise mitigation at the Neighbourhood Scale is likely to be Spatial Separation.

Spatial Separation

The most direct measure for dealing with noise problems at the Neighbourhood Scale, is to spatially separate noise sources from areas which need relatively quiet environments. This can be achieved most easily when the overall plans for a neighbourhood or a large area are first prepared.

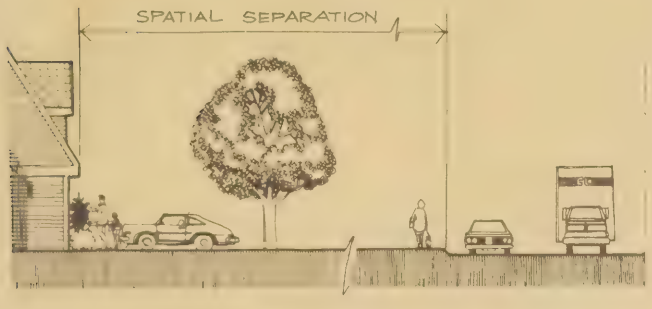
The principle of spatial separation

The principle is that land uses which might produce noise should be separated from areas which need relative quiet. Thus, industrial areas would tend to be located away from residential areas. In fact, in most urban areas special neighbourhoods are set aside exclusively for industrial purposes. (There are, however, some industries which could be located in close proximity to residential areas without harmful effects).

Limitations of spatial separation

It should be noted, however, that the effectiveness of distance alone as a noise mitigation measure is relatively limited. Stated another way, great distances are required to mitigate a given problem.

3.6 Spatial Separation: Road Noise



A TYPICAL EXAMPLE
SPATIAL SEPARATION - ARTERIAL ROADWAY NOISE

KEY VARIABLES	
TRAFFIC VOLUME	1000 v p h
PERCENTAGE OF TRUCKS	15%
SPEED	80 k.p.h. (50 m.p.h.)
ROAD GRADIENT	2%
ROAD SURFACE	NORMAL ASPHALT
ROAD HEIGHT IN RELATION TO HOUSE	SAME LEVEL
ELEVATION OF LAND BETWEEN ROAD AND HOUSE	FLAT
SOUND LEVEL 30 m (98.4 ft.) FROM THE EDGE OF PAVEMENT	65dBA
DISTANCE BETWEEN PAVEMENT AND NEAREST WALL OF HOUSE REQUIRED TO ACHIEVE 55 dBA AT HOUSE	170 METRES (557.7 ft.)

Figure 3.6 shows typical examples of the substantial distances required in using spatial separation as the only form of noise mitigation. (Although the situations used in these calculations are hypothetical, the calculations were arrived at by using the prediction models mentioned in Section 2).

The amount of land required in the Spatial Separation of a noise source from the recipient is dependent upon such factors as topography and the intensity of the noise source. Frequently large distances, not practicable in urban situations (because of high land costs), would be required to mitigate the intensity of the noise sufficiently at the receiving point. If it is possible fo find a buffer use for the area devoted to the Spatial Separation of the noise source and receiver, the cost of land may not then be a major consideration.

It may be possible to group land uses in such a way that noise sources and areas which require relatively quiet environments are buffered by land uses which do not create much noise and do not require quiet surroundings. In this way, specific active recreation facilities (such as baseball parks and arenas) might be used to separate a busy highway and a residential area. Stores along a road and related commercial uses might also act as a noise buffer between the road and houses behind.

Spatial Separation — early in the planning process

In a situation where it is possible to provide a rearrangement of land uses to facilitate a Spatial Separation which can be devoted to a use not sensitive to noise, then there are likely to be few negative financial or other consequences. This is true in circumstances where a municipal plan is being established for the first time in an undeveloped area. Indeed, the use of Spatial Separation as a noise mitigation measure must occur early in the Planning Process prior to development.

Cost of land

In most urban municipalities the cost of land is a major component of the final sale price of a home. Therefore, real and significant costs are associated with the use of land strictly for noise mitigation through Spatial Separation rather than for development.

Both the cost of land used directly for the mitigation measure and the opportunity costs must be calculated.

This opportunity cost can be thought of as the lost opportunity for additional development as a result of using land for a noise mitigation measure rather than for development. In non-urban situations where land costs are not great it is likely that the opportunity cost would not be significant. However, in most urban situations the forgone opportunity for development that may be associated with Spatial Separation is likely to exceed the cost of noise control measures that do not require additional land.

Maintenance costs

If Spatial Separation is used as the noise mitigation measure and is left as open space there may be a maintenance cost which involves such items as grass cutting and weed control. However, if the solution to the noise problem involves Spatial Separation where uses insensitive to noise are inserted in the separation, there may be no costs associated with maintenance.

Public acceptability

Public acceptance of a noise mitigation measure is an important consideration in marketing a housing development. The marketability of a development will often be influenced by the aesthetic acceptability of the noise mitigation measure.

The use of the natural landscape as a noise barrier, or the use of open space, or good land use arrangement, will likely result in a high level of acceptance by the general public.

Energy considerations

The proper arrangement of land uses could result in energy savings depending upon the direction of the noise source, and prevailing sunlight and winds. Spatial separation may result in lower residential densities within a neighbourhood which could permit residences to take better advantage of solar energy and thereby conserve traditional sources of energy. However, these lower densities may cause the transportation system of the community to be less effective and to require greater quantities of energy. Alternatively, the Spatial Separation could be accommodated by increasing residential densities incorporating attached dwelling units. This reduces energy consumption for space heating because fewer walls are exposed to the weather.

Plans of Subdivision and Site Specific Control

It is possible to plan for the control of noise at a smaller geographic scale than the neighbourhood. In addition to the overall control mechanism of the Official Plan, the municipality has in the Subdivision Approval Process, the local Zoning By-law and Site Plan Approval Process, tools wherein it can request noise abatement measures be put into effect. Each of these control mechanisms will be described briefly before discussing in detail the site planning measures which should be considered to deal with noise under any of the control mechanisms.

Plans of Subdivision

The plan of subdivision process provides a municipality with a more certain opportunity to consider site planning measures to control noise than either the general Zoning By-Law or the site plan control process.

Powers of approving agency in subdivision process

Currently, the Approving Authority for a Plan of Subdivision requests comments from various other agencies. The Ministry of the Environment is one of these commenting agencies and will comment as to whether noise control measures are required. If the Ministry of the Environment finds that some form of noise control measure is required, it will likely suggest clauses which should be included in the subdivision agreement that will ensure proper noise mitigation. If a noise problem is identified, clauses similar to the following may be included in the Condition of Draft Approval.

Conditions of draft approval

> "Prior to final approval of the plan, the owner shall engage the services of a consultant to undertake a noise study to recommend noise control features to meet the noise level objectives of the Municipality and the Ministry of the Environment to the satisfaction of the Municipality and the Ministry.
>
> Prior to the final approval of the plan, a copy of the executed Subdivision Agreement between the owner and the Municipality (specifiying the provisions required to implement the noise control features recommended by the noise study as approved by the Municipality and the Ministry of the Environment) shall be forwarded to the Ministry of the Environment."

If noise levels still exceed, by a slight amount, Provincially and Municipally acceptable noise levels, despite the inclusion of noise mitigation measures, the following provision may be included in the Subdivision Agreement.

Advertisement notice re: continued noise problems

> "Purchasers are advised that despite the inclusion of noise control features within this development area and within the building units, a slight noise level excess may exist and be of concern occasionally interfereing with some activities of the dwelling occupants."

This procedure is intended to advise the purchaser of a noise problem. In many respects it is unsatisfactory in that the noise problem continues and this may prove a difficult provision to enforce.

Zoning By-Law

It may be appropriate, where possible, to include noise controls in a Zoning By-law in the site-specific situation where a noise problem has been identified. If a rezoning is necessary, the municipality has an opportunity to review a proposed development to determine if noise mitigation measures such as Spatial Separation, Intervening Structures or even Acoustic Barriers should or should not be included.

Site Plan Control

Section 35(a) of The Planning Act

Where there is an Official Plan in effect in a municipality, it may use site plan control under Section 35 (a) of *The Planning Act* to implement changes to a site plan which would result in consideration being given to noise problems. (Section 35 (a) does not, however, provide specific jurisdiction for local Councils to bring about site plan changes only after considering the influence of noise).

Through Site Plan Control it is possible, in some circumstances, to require that the point where a machine or a fan exhausts into the atmosphere be shrouded or baffled to reduce the noise. It is also possible to require that some machines which can normally be located in the open, such as a hydro transformer, be located within a structure which will considerably reduce the noise and vibration emitted.

Site Planning Measures

Spatial Separation

Mixed use development

Within a single subdivision or building site it may be possible to separate a development into parts which might acceptably be subject to relatively high noise levels and other parts which should not be subject to much noise. In this way, for example, mixed use developments can be designed in such a way that the commercial uses act as noise buffers for the residential and recreational parts.

As noise levels in outdoor recreational areas are considered important, it may be possible to place this space so that the area is as far from the noise source as possible. This may require the placing of the dwelling unit so that it acts as a barrier to the noise. However, as well as the barrier effect provided by the dwelling, an additional distance separation is provided (although minimal) by virtue of the space occupied by the building.

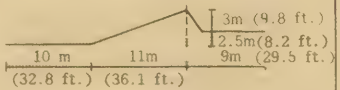
Intervening Structures

It is often not possible to plan developments where the appropriate degree of noise mitigation could be achieved through spatial separation alone. This is particularly true in older areas where land uses are often mixed. Also, transportation routes emitting noise must, by their nature, serve every part of each urban area. The following noise control measures attempt to deal with noise where it cannot be avoided through a redistribution of land uses on a site or within a neighbourhood.

3.7 Topographical Noise Mitigation

A TYPICAL EXAMPLE

TOPOGRAPHICAL DIFFERENCE - ROADWAY NOISE

KEY VARIABLES	
TRAFFIC VOLUME	1000 v.p.h.
PERCENTAGE OF TRUCKS	15%
SPEED	80 k.p.h.(50 m.p.h.)
ROAD GRADIENT	2%
ROAD SURFACE	NORMAL ASPHALT
ROAD HEIGHT IN RELATION TO HOUSE	HOUSE 2.5 m(8.2 ft.) ABOVE ROAD
ELEVATION OF LAND BETWEEN ROAD AND HOUSE	
DISTANCE OF HOUSE FROM ROAD EDGE	30 m(98.4 ft.)
SOUND LEVEL AT HOUSE IF TERRAIN WAS FLAT	65 dBA
ACTUAL SOUND LEVEL	56 dBA

The natural profile of the ground can be exploited to minimize the noise problem.

Topographic considerations

An important aspect of site planning is the consideration of the natural landscape of a given site. Rolling terrain may provide a natural acoustic barrier. If this exists, the proper positioning of buildings may result in acceptable noise levels.

The sensitive use of the natural landscape and topography as a barrier may result in a more aesthetically acceptable and less expensive solution than other forms of barriers.

Intervening structures as barriers

It is possible to construct a building as a barrier against a noise source such as a busy road. An example would be an office building built along a busy roadway, as in Figure 3.8. If properly designed and positioned, such a building could serve as an intervening structure since that structure intervenes between the noise source and the residential area. Such an intervening structure would need to be a long continuous structure close to and parallel to the road. Similarly, an apartment building could be used as a barrier to noise. (Section 4 of this report describes the techniques which would need to be implemented so as to assure acceptable sound levels within the apartment building itself.)

Apartment — Intervening Structure

3.8 Site Planning: Subdivision Scale

Office buildings separate noise source and residential area.

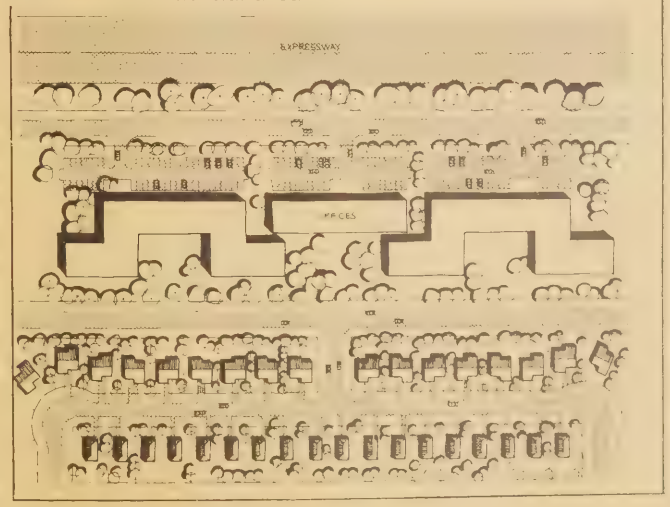


Figure 3.9 shows how an apartment building may be positioned so that it ensures the protection of outdoor recreation space. Such a structure may also shield low rise development from noise.

Townhousing and linked dwellings

A situation may occur where low and medium density housing must be built close to a relatively noisy road. (Such a situation could be avoided in some cases through careful consideration of Official Plan policies). Methods exist to create tolerable noise levels inside these houses. However, the yard space remains unacceptably noisy. In this case, it would be possible to use the house, or houses, as barriers between the road and the yard and to other properties beyond. This is more effective where the houses are linked, (as in townhousing or multiple units), creating a continuous barrier.

Where traditional design would have houses back on to a noisy road or railway line, the situation can be reversed. The rear yard could be used for car parking

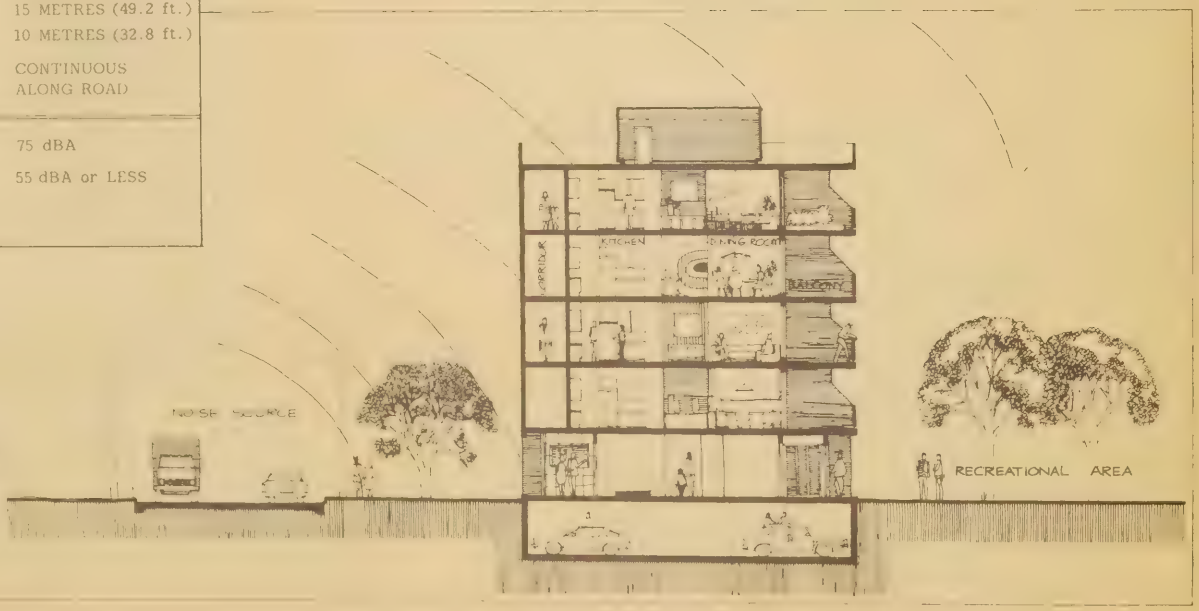
3.9 An Intervening Apartment

[illegible]	2000 v.p.h.
PERCENTAGE OF TRUCKS	15%
SPEED	80 k.p.h.(50 m.p.h.)
ROAD GRADIENT	2%
ROAD SURFACE	NORMAL ASPHALT
ROAD HEIGHT IN RELATION TO BUILDING	SAME LEVEL
ELEVATION OF LAND BETWEEN ROAD AND BUILDING	FLAT
DISTANCE OF BUILDING FROM ROAD EDGE	10 METRES (32.8 ft.)
HEIGTH OF BUILDING	5 STOREYS 15 METRES (49.2 ft.)
DEPTH OF BUILDING	10 METRES (32.8 ft.)
LENGTH OF BUILDING	CONTINUOUS ALONG ROAD
SOUND LEVEL AT BUILDING	75 dBA
SOUND LEVEL ON SHELTERED SIDE OF BUILDING (10 METRES BEHIND BUILDING)	55 dBA or LESS

Land costs of Intervening Structures

and the noise-sheltered front yard could be used for recreation and private open space. A number of different multiple unit and individual site layouts have been developed to deal with noise problems. Key-lots are one such innovation. Garages are also sometimes used as barriers to provide quiet private yard spaces.

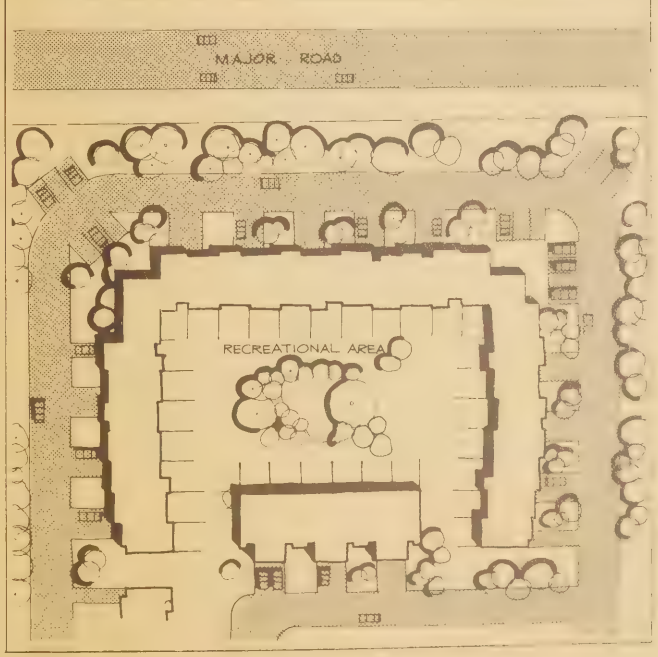
Intervening Structures are a cost effective use of land, (since the structure fulfills the dual role of providing housing and a noise barrier). Construction of the building itself may, however, be more expensive than the norm (in order to reduce the internal noise).



Apartment building acts as a barrier to noise, resulting in acceptale noise levels in the recreational area and beyond. The building must be architecturally designed internally to deal with the indoor noise problem.

3.10 Subdivision Layout

Row of continuous townhouses are designed to buffer the interior of the subdivision and their own recreational areas.



Because of the design characteristics of Intervening Structures (such as apartments where dwelling units are located on only one side of internal corridors) more internal space is required for circulation than in conventionally designed buildings. For this reason a slightly lower density may be achieved than that realized in conventionally designed buildings.

However, townhouses which act as Intervening Structures may only be different from conventional designs in that one side of the unit would have a blank wall. Low and medium density housing designed as Intervening Structures to a noise problem may require no additional land over conventional designs.

Public acceptability of Intervening Structures

Because Intervening Structures frequently are designs which are not considered conventional or traditional, many consumers may find such buildings less attractive and therefore, these buildings may be more difficult to market.

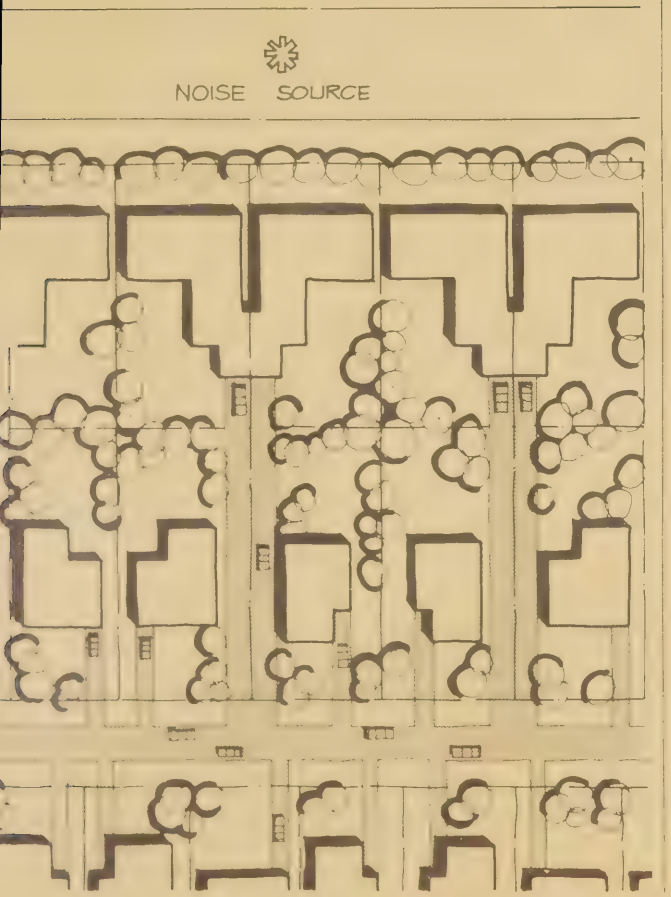
The Intervening Structure concept may produce housing such as townhouses which limit the number of door and wall openings on the side of the building closest to the noise source. These designs will not be identical to conventional townhouses and therefore some consumers may also react negatively to them.

The Intervening Structure as a noise mitigation measure should be considered at the very early design stages.

Careful consideration must be given to the placement of Intervening Structures. Locating such a structure in close proximity to a noise source is not acceptable if the safety of the building's inhabitants will be imperilled. (Such assurance may be provided if natural topography acts as part of the mitigating measure.)

3.11 Key Lot Plan

The "key lot" plan allows the houses themselves to form quiet outdoor recreational areas.



Construction costs of Intervening Structures

Intervening Structure design may require corridors in an apartment building that have apartment units on only one side of the corridor. Because of this, the circulation space to living floor space ratio in the apartment building will not be comparable with conventional designs. In this respect, construction costs related to liveable floor space may be slightly higher than for conventionally designed apartments.

Additional construction costs associated with the development of townhouses that act as barriers to noise may be minimal. Some attention should be given to walls facing the noise source as they may need to be built of material which provide good acoustic insulation.

Maintenance costs of Intervening Structures

It is unlikely that the maintenance costs associated with apartment buildings which act as barriers would be greater than conventionally designed apartment buildings.

The individual owner of townhouses or linked dwellings that act as barriers may find that there are certain minor aspects which require additional maintenance costs. This may include the removal of snow in a key lot design where some homeowners may have driveways which are longer than their neighbours.

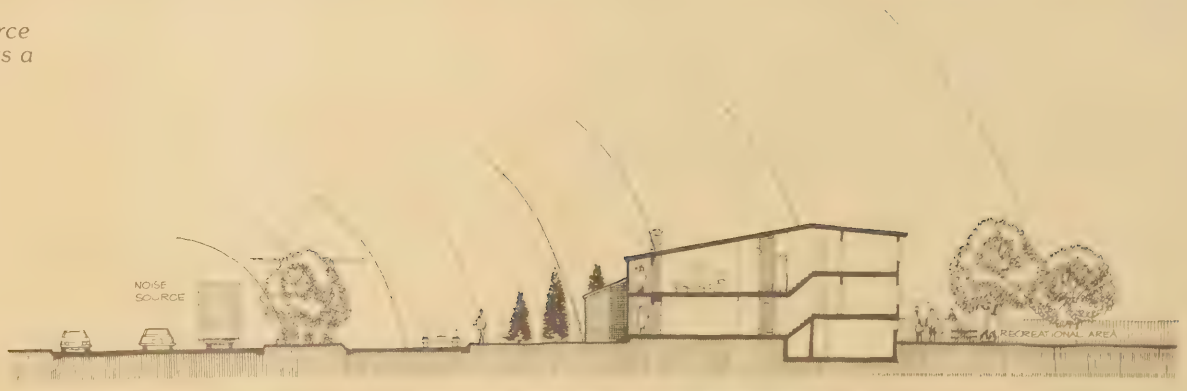
Energy considerations

Intervening structures are usually designed so as to minimize wall openings such as windows and doors on the side of the structure facing the noise source. If this side of the building faces south, then the potential for windows to benefit from solar exposure is diminished. However, the potential exists to use "blank" walls as solar collectors. In short, each site is unique and energy conservation should be considered in land use planning solutions intended to control noise.

Although it is possible to include intervening structures after Draft Plan Approval of a given subdivision, it is wise to consider this mitigation measure at an early stage in the planning process since the size and shape of the building is a determinant of subdivision block configuration, lotting and street layout.

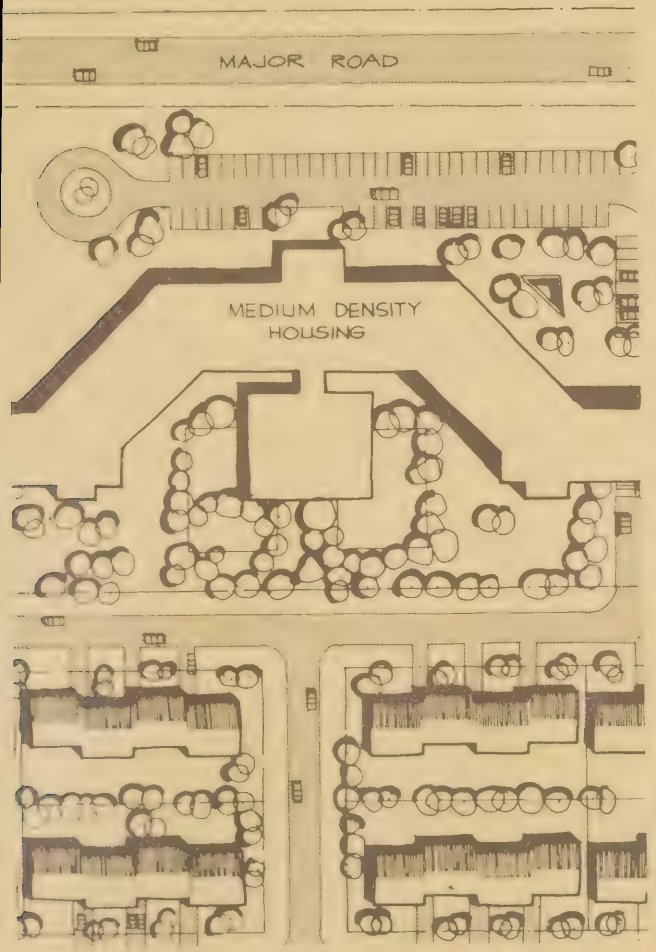
3.12 House as a Barrier

House separated from noise source by minor road. The house acts as a barrier for the recreational area.



3.13 Intervening Medium Density Housing

If the apartment building is not built, the noise protection for the low rise homes will not be realized.



It is important in many cases to consider when the intervening structure, intended to act as a barrier to other residential areas, is going to be built. For example, if the medium density housing in Figure 3.13 is not built before the other homes, the other homes will be subject to excessive noise levels. In such situations a municipality may deem it appropriate to phase development. Such phasing would ensure the medium density housing, or intervening structure, is built prior to the rest of the plan.

4. Other Noise Control Measures

Acoustic Barriers

In this report acoustic barriers are defined to be earth berms, walls or fences that effectively act as barriers to noise. Unlike the intervening structures discussed in Section 3, these types of barriers are rarely useful in their own right as part of a development. For this reason they should be considered as a secondary measure in the planning process after careful consideration has been given to the Land Use Planning measures discussed earlier.

Characteristics of a good barrier

Acoustic Barriers, in order to be effective, must be solid, continuous, without holes or gaps and be reasonably dense. No line of sight should exist between the noise source and the area being shielded, if the barrier is to properly function.

The ends of the barrier should extend well beyond the area to be shielded from the noise. (More detailed information concerning the design characteristics of acoustic barriers can be found in some of the publications listed in Appendix 6.5 of this report.)

The effectiveness of the barrier depends on its height above the noise source, the height of the structure it is intended to shield, its length and its position between the noise source and the noise sensitive area.

Barriers must be designed so as to block the line-of-sight between the noise source and the receiver. For this reason barriers are most effective for structures at low levels. Upper storeys of high apartment buildings will not be protected if the sound passes over the top of the barrier.

Earth Berms

An earth berm is a mound of earth running parallel to a linear noise source such as a roadway. Its purpose is to act as a barrier against the noise source.

Berms require a considerable amount of land for their erection. For example, a 3 metre (9.8 foot) berm with a 3:1 side slope requires an 18 metre (59 foot) base. This 3:1 slope is necessary to assure ease of maintenance. Steeper slopes are possible but the berm may require some reinforcement and will likely present problems with respect to maintenance.

Cost of land for a berm

Irrespective of the slope of a berm, it is likely to occupy a considerable amount of land. This land will be very expensive in most urban situations.

4.1 Berm Barrier

The berm acts as a noise barrier to reduce sound levels in the recreational area. It is not effective for upper storeys.

Public acceptability

In general, the erection of Berms is indicative of a noise problem in the area. This may be a negative selling feature. However, some people may perceive the Berms as offering them a greater degree of privacy and protection. Other consumers may feel that the noise problem has been solved by the inclusion of a Berm and therefore will consider this feature in a positive light.

Some house buyers will prefer the option of a landscaped berm as opposed to a fence. (The landscaping of a berm with shrubs and evergreen trees can cut noise only a small amount but may offer aesthetic appeal.)

Maintenance costs of berms

Although berms may be considered to be a more aesthetically pleasing noise mitigation measure than walls, they require considerably more work to maintain their appearance. Sodded Earth Berms will require regular mowing and weed control. Berms will require some "clean-up" cost associated with them as their construction interferes with wind circulation that will result in the accumulation of debris or snow. Additionally, Berms can act as barriers to drainage which may pose problems for drainage swail function and maintenance.

Sound reflection

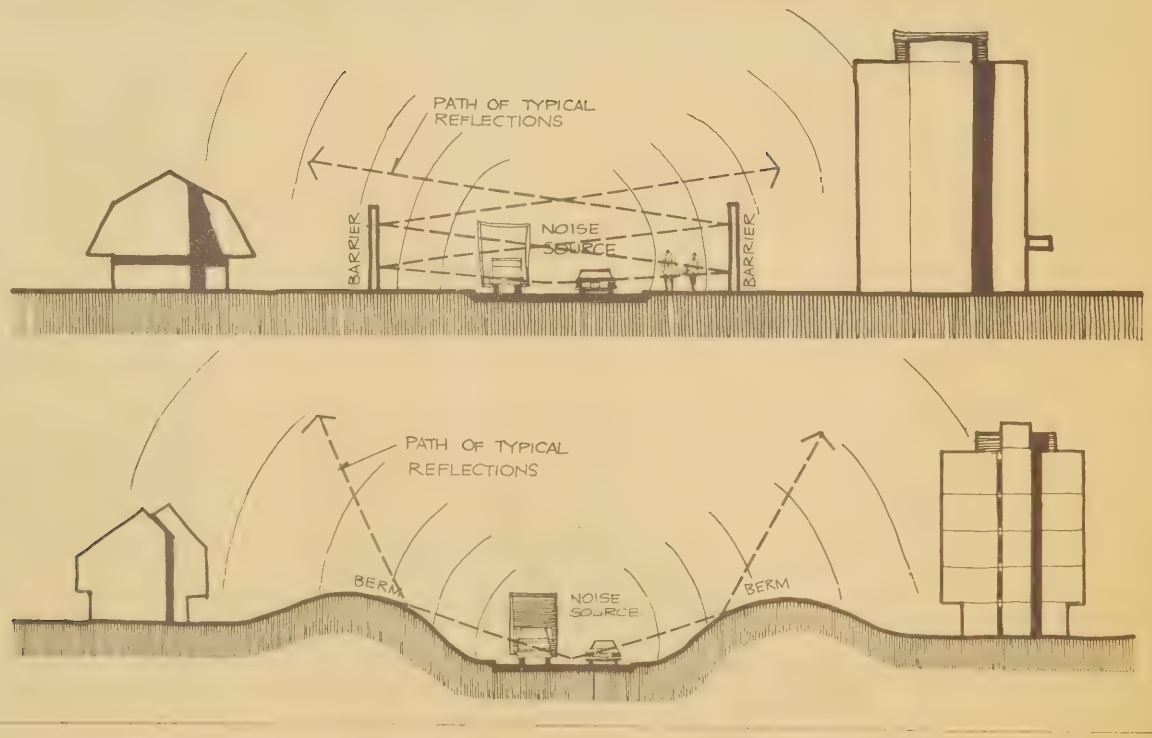
The sloping surface of a berm deflects sound waves upwards rather than towards the opposite side of the roadway or railway. Therefore, noise levels on the opposite side of the roadway will not increase as much with a berm as they will with a wall barrier. Additionally, sodded berms provide better sound absorption (and therefore, less reflection) than do walls. Figure 4.2 illustrates in a schematic manner the way in which sound may be deflected by berms. This same figure indicates the possibility of the dispersion and reflection of noise. Without careful design the erection of an acoustic barrier may even amplify the noise problem for nearby areas.

The costs of constructing a berm are to some extent dependent upon the availability and proximity of fill. However, even a small berm will require a considerable volume of fill.

Berms may cause wind effects which would increase space heating requirements.

4.2 Sound Reflections: Berms vs Walls

Both sides of a noise source should be considered when analysing noise problems. Reflections of sound in the illustration would be worse with barrier walls than utilizing earth berms.



Depending on site specific conditions, the opposite may also be true. (Although it is unlikely that homes located within Earth Berms are practicable in most urban communities, it is possible such homes could be energy efficient and effective as noise barriers.)

A potential problem exists with Berms in that they may need to be located in close proximity to roadways. Their location may result in poor visibility for the driver. Another problem which may arise from the use of Berms is the potential hazards for children playing on the berms near freeways or railways.

Although it may be possible to provide for Berms after the residential development has been completed, it is wise to consider this solution at an early stage to facilitate the erection of the Berms.

Walls and Fences

In order for walls or fences to act as effective noise mitigation measures, they must be continuous, have very few holes and be of a sufficient density to deflect sound waves. They may be used to supplement the height of a berm by incorporating a wall or fence on the top of a berm.

Implications of walls and fences

Walls and fences which effectively mitigate noise have the advantage of requiring less maintenance and less space than an earth berm. They also provide a strong psychological separation between the noise generator and receiver.

The main function of a solid wall or fence is likely to be noise mitigation and therefore, may draw attention to the fact that a noise problem does exist. It is generally agreed that these barriers are not considered aesthetically pleasing.

4.3 Barrier Walls

A TYPICAL EXAMPLE

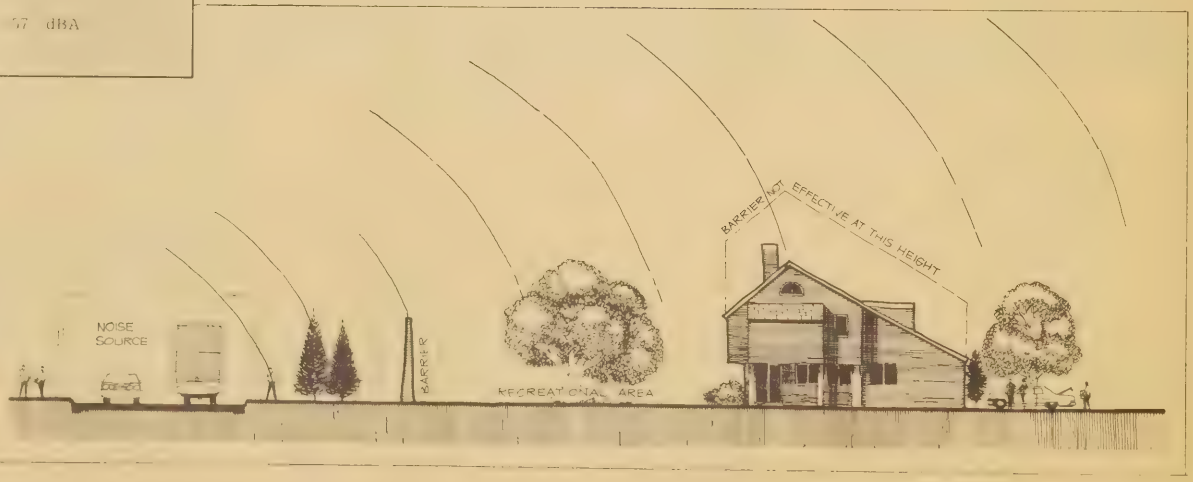
BARRIER WALL - ROADWAY NOISE

KEY VARIABLES	
TRAFFIC VOLUME	1000 v.p.h.
PERCENTAGE OF TRUCKS	15%
SPEED	80 k.p.h (50 m.p.h.)
ROAD GRADIENT	2%
ROAD SURFACE	NORMAL ASPHALT
ROAD HEIGHT IN RELATION TO HOUSE	SAME LEVEL
ELEVATION OF LAND BETWEEN ROAD AND HOUSE	FLAT
DISTANCE OF HOUSE FROM ROAD EDGE	30 METRES (98.4 ft.)
HEIGHT OF BARRIER WALL	3.6 METRES (11.8 ft)
DISTANCE OF BARRIER WALL FROM ROAD EDGE	10 METRES (32.8 ft.)
SOUND LEVEL AT HOUSE WITHOUT BARRIER WALL	65 dBA
SOUND LEVEL AT HOUSE WITH BARRIER WALL	57 dBA

Considerations of structural stability may be of importance in walls or fences in excess of 3.0 metres (9.8 feet). In order to ensure that the wall or fence is of sufficient density, either Wood, Concrete or Steel is used in their construction. As such, maintenance costs may be relatively low with the exception of periodic painting.

Because of the materials required in the construction of an acoustic wall or fence the costs should not be compared to a conventional privacy fence. In fact, costs are likely to be well in excess of conventional fence designs.

Walls and fences will have similar problems/benefits as berms with respect to energy concerns and safety problems.



Continuous barrier to reduce sound levels in the recreational area. Barrier mostly effective at grade level, would not be effective for upper storeys.

Since walls and fences may require little space for their erection, it is possible to consider their inclusion in a development late in the planning process. However, it is recommended that noise control measures be considered at the earliest possible stage in the planning process to assure the implementation of the best noise control measures.

Building Design

During the design phase of the actual building it is impossible to incorporate features which will affect the level of indoor noise in a dwelling.

Room arrangement

Within a house there are noise sensitive areas which include bedrooms, living rooms and dens. Less noise sensitive areas may include kitchens and bathrooms; while hallways, storage rooms and closets are not sensitive to noise. By careful arrangement of these areas, the internal separation of sensitive areas from the noise source may result in acceptable noise levels being achieved.

Windows

By limiting the number and size of wall openings on the side of a dwelling exposed to noise, internal noise levels will be reduced.

However, the design of houses should consider noise as one of many concerns. For example, windows are normally planned with consideration of light, ventilation and energy in mind. The absence of windows on one side of a dwelling may in turn require a special ventilation system or air conditioning.

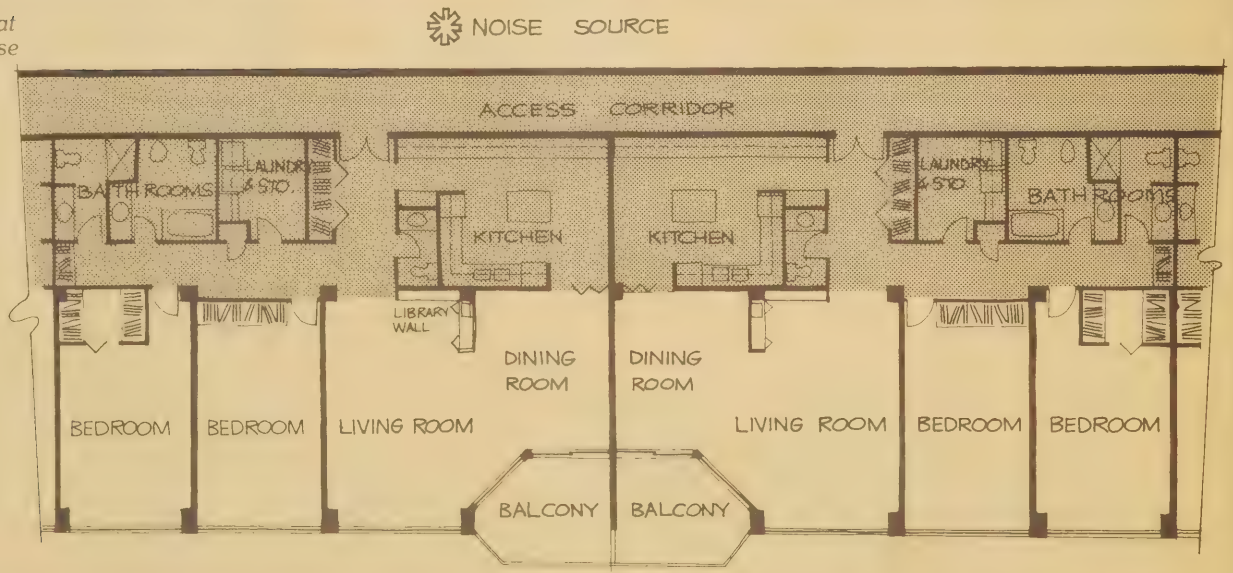
The rearrangement of a house design to accommodate noise concerns may produce a building with an unusual appearance and this may in turn result in difficulties in marketing the unit.

Public acceptability Provided the internal layout of a dwelling unit has been sensitively designed, it is unlikely that all consumers would reject a departure from the normal housing form. However, some consumers may object to various components of their living quarters being placed at the front or back of a unit.

Construction costs There may be no direct costs associated with Building Design to control noise. However, in the case of an apartment building, where corridors have units on only one side, construction costs are effectively higher since net useable residential space is served by almost twice as much circulation (corridor) space.

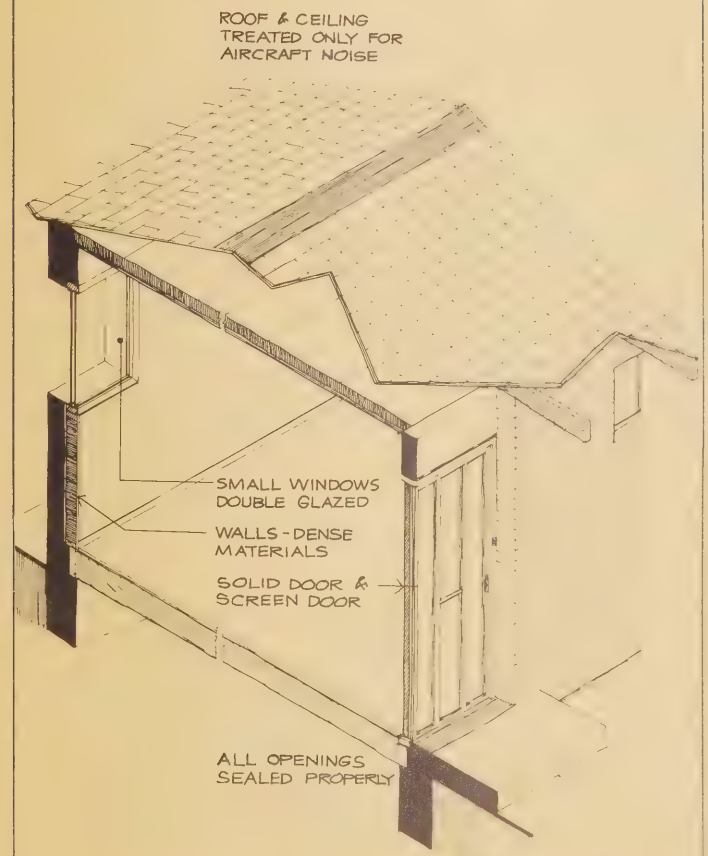
4.4 Building Design

Building planned internally so that the elements not sensitive to noise (corridor/kitchens/bathrooms) buffer the living/sleeping areas.



4.5 Construction Techniques

The various building components and materials can help to reduce sound levels indoors.



Specific site characteristics will determine whether or not a particular building may be designed so as to minimize the impact of noise while maximizing benefits from solar exposure or shielding from wind. If solar exposure can be maximized while wind exposure is minimized, space heating requirements for the building should be reduced, resulting in energy savings.

Dependent upon the configuration of the approved Draft Plan of Subdivision it is possible that Building Design taking into account noise pollution could be undertaken late in the planning process. However, consideration of noise at the earliest stages in the planning process could result in better Building Design, since lots could be created that would best accommodate the proposed structure.

Construction Techniques

In most residential developments where outdoor noise levels are at acceptable limits, standard construction techniques and building code requirements are adequate to reduce inside noise levels to acceptable limits.

Further reduction of indoor noise levels is possible through the use of special construction techniques, materials and design details. It is beyond the scope of this report to describe these techniques in detail but they include such items as:

- Increasing the airspace, thickness and density of materials used in walls.

Making windows as small as possible, sealing them properly, increasing glass thickness, and using various forms of double glazing. (Air conditioning may become necessary in conjunction with these measures).

Using a solid core door and adding a screen door or double door.

(Roofs and ceilings are usually only treated where there is a severe problem with aircraft noise).

Buildings should be properly sealed

The single most important method of conserving energy and noise reduction involves sealing air leaks in the building. One study indicates that a building sealed for energy conservation would realize an internal noise reduction of between 5 and 10 dB. (Source: "Energy Conservation and Noise Control in Residences", David N. Keast from "Sound and Vibration"; July 1979.)

Implications of construction techniques

Construction techniques that reduce indoor noise levels will require no additional property for their implementation. It is unlikely that they will encounter public resistance as acoustic insulation and heavier glass in windows are not likely to be perceived by the average consumer.

No additional maintenance costs can be attributed to construction techniques nor can any potential safety problems be perceived.

Noise should be considered at the earliest stage in the planning and design of a residential development; however, construction techniques sensitive to noise can be implemented when building permits are requested.

All of these measures add to the capital cost of the dwelling unit, while air conditioning will add to the operating costs of a house. Although aesthetically and functionally acceptable, construction techniques should only be considered if other solutions are not feasible.

5. Case Study: Secondary Plan

This Section of the report provides a case study of a situation where noise control measures have been considered. The example involves the preparation of a Secondary Plan which has considered the impact of a major freeway on the community.

Figure 5.1 is a map of the area. It can be seen from this figure that large portions of land, identified for residential development in the Secondary Plan for the area (Figure 5.2), have not been developed.

Noise mitigation considered as part of comprehensive planning

The Municipality, for several reasons, deemed it appropriate to review the Secondary Plan for the community. There was concern over the apparently high population targets for the area, the change in community character that might result if these targets were achieved and a realization that the environment along the Freeway was inappropriate for residential development. Specifically, a planning staff report noted:

> "It is recognized that the environment along the freeway is inappropriate for residential development and that non-residential uses, particularly high quality light industrial development, should be encouraged to buffer the freeway noise and fumes from planned residential development to the south."

5.1 Existing Community

An opportunity existed to reconsider the Secondary Plan because major areas of the community were still undeveloped.

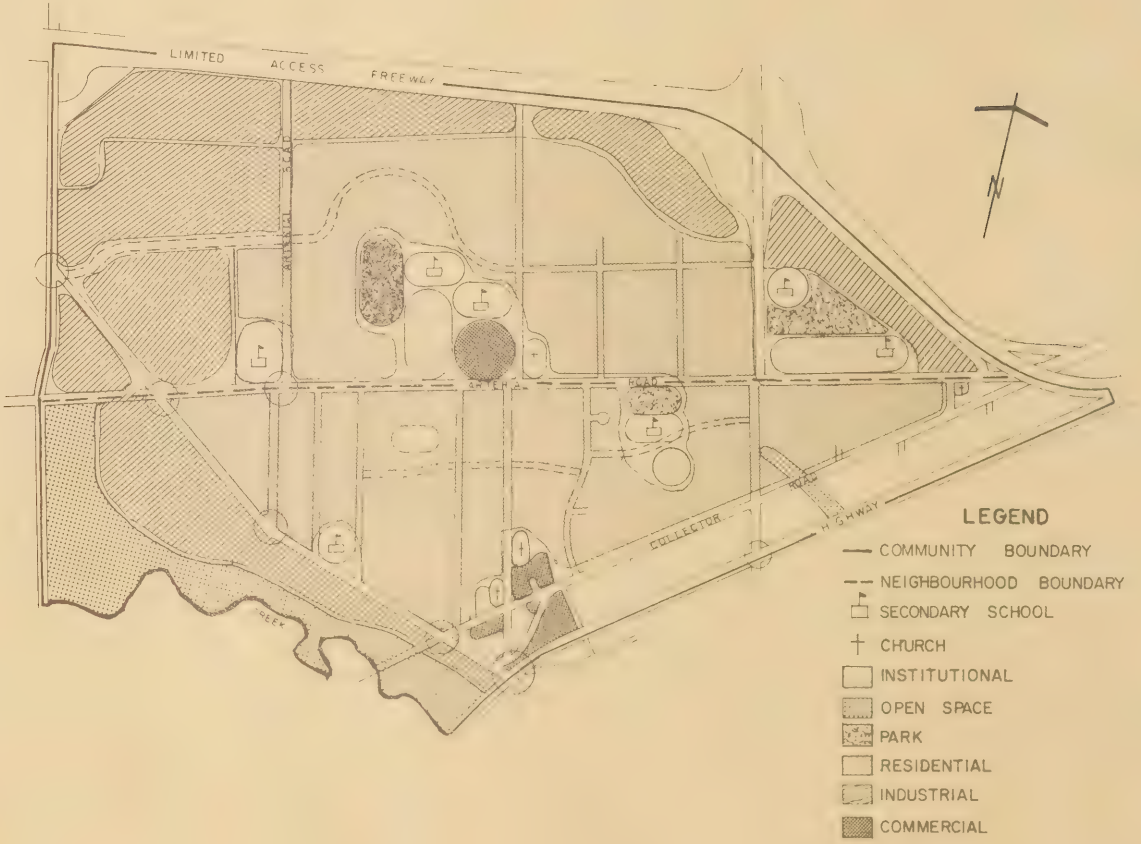
5.2 Existing Secondary Plan

This plan was not developed with noise as a major criterion. Lands adjacent to the highway were designated for residential development.

Figure 5.3 is the proposed re-arrangement of land uses for the community. It designates large parcels of land abutting the Freeway as General Industrial Uses with High Performance Standards. This rearrangement of land uses provides a buffer to the proposed housing from the noise generated from the freeway.

5.3 Proposed Secondary Plan for Community

The proposed Secondary Plan designates major portions of land for industry which will act as a buffer to the noise generated from the highway.



6. Appendices

6.1 The Nature of Sound

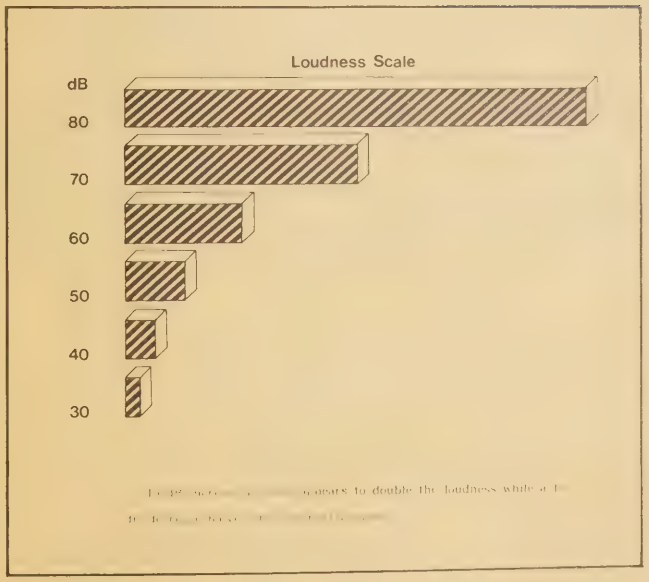
NOISE is how individuals describe sounds which are unpleasant or annoying. Because the human ear is capable of responding to a wide range of sound intensities or ACOUSTIC PRESSURES a logarithmic scale is used in sound measurement. The louder a given sound the greater the reading on the LOGARITHMIC SCALE of sound measurement. The "units" which are used on this scale are referred to as DECIBELS and are in some ways comparable to the degrees measured on a temperature scale. However, unlike conventional temperature scales, the decibel scale is so designed that a 10 decibel increase in level appears to double the loudness or intensity of a given sound.

For the measurement of sound various scales have been developed. In the assessment of COMMUNITY NOISE (e.g., highways) an "A" weighted scale is used. This "A" WEIGHTED DECIBEL SCALE (dBA) is designed to reflect human sensitivity to sound.

In the assessment of AIRPORT NOISE an EFFECTIVE PERCEIVED NOISE DECIBEL (EPNdB) is used from which useful NOISE EXPOSURE FORECAST contour maps are developed.

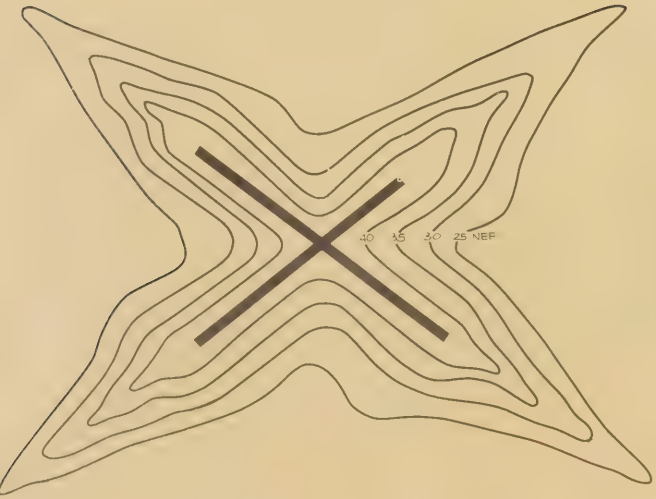
Noise levels which exist in the community vary with the time of day. For example, many roadways generate greater noise during the "rush hour" period when most people travel to work. Just as it would be a poor indicator of the day's temperature to take one instantaneous temperature reading rather than the average of several readings, it is wise to "average" many measurements of a particular noise taken at different times over an extended time period.

6.1.1 Apparent Loudness



6.1.2 Airport Noise Contours

A technique for illustrating the perceived noise around airports.



Fluctuations in traffic flow, for example, would if measured with a simple sound meter, result in a series of fluctuating readings. This TIME VARYING NATURE OF COMMUNITY NOISE requires a means of measuring noise which best reflects its annoyance value. Such a descriptor has been developed for time varying noise and is termed the EQUIVALENT ENERGY CONTINUOUS LEVEL (Leq.). This sound descripter characterizes human response to varying sound over a given time.

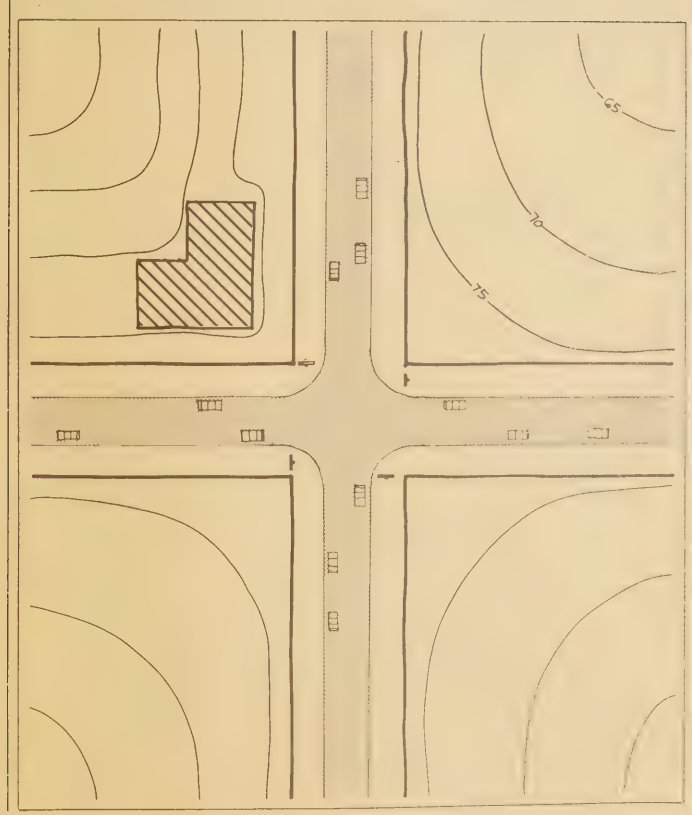
A similar descriptor has been developed to account for the time varying nature of noise associated with airports. This descriptor takes into account the types of airplanes and frequency with which they land and take-off from a given airport. It is possible to develop NOISE EXPOSURE FORECASTS (NEF), based on calculations which make use of the EFFECTIVE PERCEIVED NOISE DECIBEL (EPNdB), for airports.

6.2 Sound Level Policies and Guidelines

Given that noise can exert a detrimental impact upon those affected by its influence it is desirable to establish sound level limits beyond which noise levels will not be tolerated. The field of noise control is relatively new and still evolving. Acceptable sound level limits are currently being defined for some situations while Provincial Government policy exists in others. The principal concern in setting these limits is human response to noise.

6.1.3 Leq Noise Contours

A technique for illustrating the perceived noise around roads, railways and industries.



In evaluating human response to noise, one could consider:

a) the annoyance of a particular noise in relation to the continuous sound level of the community or AMBIENT noise level;

b) the standard or STATUS QUO noise levels of many communities;

c) the INTERFERENCE with SPEECH, SLEEP or specific TASKS such as reading;

d) the potential for HEARING DAMAGE (such potential is likely to be minimal except in extreme cases of continuous exposure to high noise levels);

e) the percentage of people ANNOYED by certain noises; and

f) the evaluation of COMMUNITY COMPLAINTS related to noise nuisance.

The establishment of acceptable levels of community noise involves consideration of all of the above factors and is a complex task (Appendix 6.1, The Nature of Sound, provides a brief explanation of the descriptors which have been developed to reflect this community response to noise).

Sound level limits have been developed for both indoors and outdoors. The outdoor levels are intended to apply to an outdoor recreational living area (designed to accommodate activities which would include conversation and relaxation) immediately adjacent to the housing unit.

6.2.1 Ministry of the Environment Sound Level Guidelines

INDOOR SOUND LEVEL LIMITS	
TYPE OF SPACE	EQUIVALENT SOUND LEVEL (Leq) dBA
Bedrooms, sleeping quarters, hospitals, etc. (Time period 23:00 - 07:00 hours)	40*
Living rooms, hotels, motels, etc. (Time period 07:00 - 24:00 hours)	45**
Individual or semi-private offices, small conference rooms, reading rooms, classrooms, etc. (Time period 07:00 - 23:00 hours)	45
General offices, reception areas, retail shops and stores, etc. (Time period 07:00 - 23:00 hours)	50

SOUND LEVEL LIMITS FOR OUTDOOR RECREATIONAL AREAS (07:00 - 23:00 HOURS)	
SOUND DESCRIPTOR FOR THE ENTIRE PERIOD	SOUND LEVEL LIMIT dBA
L_{50}	52
Leq	55

SOUND LEVEL LIMITS FOR OUTDOOR AREAS (23:00 - 07:00 HOURS)	
SOUND DESCRIPTOR FOR THE ENTIRE PERIOD	SOUND LEVEL LIMIT dBA
L_{50}	47
Leq	50

* CMHC requires 35 ** CMHC requires 40

(both over a 24 hour time period)

Specific standards of acceptable noise levels have been established, by the Province, for aircraft noise and for freeway noise. Both of these provincial policies are included in full at the end of Section 6.2. These standards have been set to ensure a reasonably comfortable living environment inside and outside of the house. The Province prohibits residential development in areas where these standards are (or would be) exceeded.

Figure 6.2.1 indicates the sound level guidelines recommended by the Ministry of the Environment. These sound level limits relate to Community Noise Levels. These limits are intended as guidelines upon which municipalities may develop sound level limits acceptable to their jurisdiction.

Land Use Policy Near Airports

Ontario-Ministry of Housing, March 1978

Provincial land use policies established in 1969 to protect lands near airports have been revised by the Ministry of Housing through the adoption of a more accurate system of measuring discomfort caused by aircraft noise.

The new policy is based on the NEF (Noise Exposure Forecast) system which reflects the noise produced by all types of aircraft at an airport, taking into consideration the number of flights, the duration of the noise, the time of day and the frequency components of the sound (pure tones). All land use proposals near airports must now adhere to the NEF Land Use Compatibility Table (6.2.2). The applicable NEF values should be determined from NEF or NEP contour maps, based on contours supplied by Transport Canada or by the Department of National Defence (6.2.5). This table has been designed to reflect CMHC policy related to residential development* and also contains policies for non-residential uses.

* New Housing and Airport Noise, N.H.A. 5185 Metric Edition

6.2.2 NEF Land Use Compatibility Table

Land uses (1)	Noise exposure forecast values				
	0	28	30	35	40
Group I residential, passive use park, school, library, church, theatre, auditorium, hospital, nursing home, camping or picnic area	In this range, noise is not usually a problem.	Discretionary Range All buildings must conform to Acoustic Design Criteria (2) (3).	Some annoyance will occur in this range but residential development will be acceptable if approved by the municipality (2).	No new Group I uses may be established in this range, except those for which the outdoor environment is irrelevant and which meet the Acoustic Design Criteria (3).	
Group II hotel, motel, retail or service commercial, office, athletic field, playground, stadium, outdoor swimming pool.	In this range, noise is not usually a problem.		Discretionary Range The characteristics of each proposed use must be studied and appropriate noise insulation must be incorporated into building design (3).		Group II uses may not be established beyond the 40 NEF contour unless the are adequately insulated indoor uses (3).
Group III Industrial, warehousing, arena, general agriculture, animal breeding (4).	In this range, noise is not usually a serious problem			Discretionary Range Most Group III uses are permissible in this range, provided ancillary uses are adequately insulated (3).	

Notes

(1) Uses not specifically mentioned should be compared to the uses listed, classified in the most appropriate Group and regulated accordingly.

(2) For residential uses, refer to "New Housing and Airport Noise", N.H.A.5185-1-78 and any amendments thereto. Acoustic design must include adequate ventilation. The developer of a residential project must undertake to inform prospective tenants or purchasers of the possible noise problem.

(3) For non-residential uses, refer to the Acoustic Design Criteria next page.

(4) Research has shown that most animals become conditioned to high noise levels. However, no farms and any use likely to create a bird hazard, such as a feed lot or stock yard, should not be located closer to an airport that, as recommended by Transport Canada in "Land Use in the Vicinity of Airports", document S-77-4.

6.2.3 Correction Factor (Table 1)

Hotel, motel	no correction
Private office area, conference room etc.	-5
General office areas, retail stores	-10

Hospitals, theatres, auditoriums, churches, libraries, schools and nursing homes are subject to the same requirements as residential uses.

6.2.4 Acoustic Insulation Factor (Table 2)*

No. of components forming room envelope	NEF

* Table 2 of the CMHC handbook "New Housing and Airport Noise" (1978 edition), expanded to include NEF values above 35.

The general principle underlying the restrictions is that the outdoor noise level should govern permissible uses of a property. However, some indoor uses which make almost no use of the outdoors may be permitted to almost any noise level provided they meet CMHC standards for acoustic insulation and ventilation. The latter requirement is necessary to ensure that the acoustic insulation value is not lost through the opening of windows.

ACOUSTIC DESIGN CRITERIA FOR NON—RESIDENTIAL USES

The procedures described in Section E of "New Housing and Airport Noise" should be adapted to meet required sound insulation for non-residential buildings. Figure 6.2.3 (Table 1) shows the correction factor to be used with Figure 6.2.4 (Table 2) of the CMHC handbook to determine the Acoustic Insulation Factor (AIF) for other uses. AIF values corresponding to NEF values above the 35 contour are obtained by extrapollation from the figures on Figure 6.2.4 (Table 2).

Example 1

The AIF for a retail store within the 30 contour, assuming the room has 3 components, would be 30-10=20.

With reference to Table A of the CMHC handbook, assuming a window area =30% of the floor area, the window could be a single pane of 2 mm glass. Within the 40 contour, the AIF would be 40-10=30 and a similar store would need a single pane of 4 mm or 5 mm glass.

Example 2

A private office associated with an industrial use in the vicinity of the 45 NEF contour would have an AIF of 46-5=41. (Assuming 4 components). Assuming a window area =25% of the floor area, triple glazing (a WT2-Wl window) would be required.

6.2.5 NEF and NEP Contour Maps

NEF CONTOUR MAPS		
Airport	Date of Latest Revision	Projection Date
Ottawa	June, 1972	Summer 1976
Hamilton	April, 1973	**
London	January, 1975	Summer 1978
Thunder Bay	October, 1974	1976+
Carp	May, 1973	**
Kingston	September, 1978	1986
Sudbury	June, 1973	1976
Buttonville	August, 1973	**
Toronto Island	April, 1978	1990
Oshawa	August, 1978	1985
Maple	September, 1973	**
Waterloo-Wellington	April, 1977	1985
Sault Ste. Marie	September, 1974	1976
C.F.B. Trenton	January, 1979	1984
Brantford	August, 1977	1991
North Bay	August, 1978	1985
Sarnia	August, 1978	1986
Pembroke	October, 1978	1986
Wiarton	February, 1979	**
Toronto (Malton)*	August, 1979	1986

NEP CONTOUR MAPS		
Airport	Date of Latest Revision	Projection Date
Windsor	October, 1978	[illegible]
Toronto (Malton)*	July, 1976	[illegible]

Table updated in January 1980

* Land use proposals should not conflict with the 1995 NEP or with the 1986 NEF contours for Toronto (Malton).

** General Aviation (No date).

NEF CONTOUR MAPS

The currently available NEF contour maps which should be used are listed in Figure 6.2.5. With the exception of Toronto International Airport (Malton), they are obtainable from local offices of the Canada Mortgage and Housing Corporation (C.M.H.C.). The Toronto Malton map is available from the Local Planning Policy Branch, Ministry of Housing, 3rd Floor, 56 Wellesley Street West, Toronto M7A 1K4. (416-965-3938).

NEP CONTOUR MAPS

In some cases, the relatively short-range NEF maps published by C.M.H.C. are not considered appropriate by the Ministry of Housing for land use planning purposes and the Noise Exposure Projection (NEP) contours representing a longer range projection should be used. The NEP contour maps which are currently available from the Local Planning Policy Branch, Ministry of Housing, are listed in Figure 6.2.5.

Up-to-date contours for other airports are scheduled to be produced by Transport Canada and will be added to the list. In addition, it is expected that existing contour maps will be reviewed and updated from time to time.

Guidelines on Noise and New Residential Development Adjacent to Freeways

Ontario-Ministry of Housing, April 1979

MINISTER'S STATEMENT ON NOISE AND NEW RESIDENTIAL DEVELOPMENT ADJACENT TO FREEWAYS

Mr. Speaker:

In February of 1977, the Ministers of Transportation and Communications and Housing announced that, "where feasible," noise barriers would be provided by the Ministry of Transportation and Communications for new construction work on major freeways through existing residential areas. It was also stated that developers of new residential units near freeways would have to include similar measures to reduce noise impact.

We are now able to introduce guidelines to control the noise in outdoor areas of new residential developments near freeways. I am pleased to announce a new policy which has been formulated in consultation with the Ministries of Environment, and of Transportation and Communications.

Briefly, Mr. Speaker, this new policy sets an objective of 55 decibels as an outdoor noise level in residential developments adjacent to freeways. Where the outdoor noise level is likely to be excessive, the developer must demonstrate that measures will be taken to get as close as possible to this objective level of 55 decibels.

In those cases where the attenuated outdoor noise level exceeds 70 decibels, residential development will be prohibited, because this is the level where extensive community dissatisfaction occurs.

My ministry, in co-operation with the Ministries of the Environment and of Transportation and Communications, will be forwarding guidelines on outdoor noise levels for new residential development to all municipalities. This material also indicates some techniques which could be used to reduce the noise impact. Copies of these guidelines will also be provided to all members.

Noise control guidelines are also being prepared relative to the indoor sound environment, and these should be ready in the near future.

GUIDELINES ON NOISE AND NEW RESIDENTIAL DEVELOPMENT ADJACENT TO FREEWAYS

Introduction

A policy dealing with current problems of freeway noise in existing residential areas and with noise problems associated with freeway construction or reconstruction through existing residential areas was jointly announced by the ministers of Transportation and Communications, and of Housing in February 1977. It stated that, "where feasible", noise barriers would be provided and that a developer, proposing to build residential units adjacent to a freeway, would be required to take appropriate measures to reduce noise impact.

It is unrealistic to suggest prohibiting all new residential development close to freeways since it is often technically, administratively and economically practicable to design new developments and/or incorporate measures in such a manner that noise is reduced to acceptable levels. Also, it is recognized that developers have varying degrees of flexibility to attentuate sound.

Consequently, it was considered desirable to establish sound level limits for noise control in outdoor recreational areas for new residential development adjacent to freeways. (Appropriate noise control guidelines are being prepared by the Ministry of Housing to ensure that the indoor sound environment of new residential development near freeways is also protected.)

Definition of 'Freeway'

For the purposes of this policy, "freeway" is defined as an existing completed, partially developed or proposed provincial or municipal divided arterial highway that is

accessible only from intersecting arterial streets at grade-separated interchanges.

Definition of 'Outdoor Recreational Area'

For the purposes of this policy, "outdoor recreational area" is defined to mean an outdoor living area immediately adjacent to the housing unit designed to accommodate a variety of individual outdoor activities.

Sound Level Measurement

For the purposes of this policy, the noise level is the A-weighted 24-hour equivalent (Leq) sound level based on either the Average Annual Daily Traffic (AADT) data or, where available, the Summer Average Daily Traffic (SADT) data whichever is the higher. The equivalent (Leq) sound level is a good indication of how people react to freeway noise.

Generally, the public reacts to noise when sound levels in outdoor recreational areas exceed 55 decibels (dBA). Public concerns, dissatisfaction, and complaints increase rapidly from approximately this level.

POLICY ON NOISE AND NEW RESIDENTIAL DEVELOPMENT ADJACENT TO FREEWAYS

- The objective for predicted sound levels in outdoor recreational areas is 55 dBA or less.
- The province will not impose additional noise attenuation on the developer where the level is at or below the objective level.
- The developer shall be required to prove to the satisfaction of the approving authority, in accordance with provincial guidelines, that the noise level in outdoor recreational areas after applying attenuation measures is the lowest level technically, administratively and economically practicable. Any consideration of relief from achieving the objective level will be based on specific site characteristics, such as topography, existing development and the available sound attenutation options. Residential development will be prohibited where the attenuated sound level in outdoor recreational areas will exceed 70 dBA.
- The Ministry of Transportation and Communications shall plan to achieve an attenuated sound level as low as technically, administratively and economically practicable below 70 dBA where a freeway is proposed to be built or expanded through a developed residential area.
- Where the noise levels are expected to exceed 55 dBA in outdoor recreational areas after the implementation of sound attenuation measures, the approving agency for any new residential development shall require as a condition of approval that the developer inform prospective purchasers of residential lots which are so affected of the noise situation by posting a sign or by other appropriate means.
- Where residential development for which noise control measures will be required precedes the construction of a designated freeway, the approving agency may require as a condition of approval that:
  (a) sufficient lands be conveyed at no cost for erection of a noise barrier; and/or,
  (b) a pro-rated cost contribution be made prior to final approval for barrier construction, if barriers are considered necessary at the time of final approval.

Purpose of Guidelines

The purpose of these guidelines is to ensure that sufficient data is made available by a developer to the approving authority demonstrating the achievement of the lowest technically, administratively and economically practicable noise levels for new residential development, in accordance with the provincial policy on Noise and New Residential Development Adjacent to Freeways. The analysis and evaluation by the approving authority will consist of checking the validity of the submission based on the best available acoustical information.

Noise Control Measures

In order to obtain relevant information for noise atten-

ıation, a developer should make early contact with the Ministry of the Environment when the development is within one kilometre of the edge of a freeway right-of-way. The distance may vary with different conditions of traffic, topography and existing development.

Any consideration of relief from achieving the objective level of 55 dBA will be based on specific site characteristics, such as topography, existing development and the available noise control options. Control measures may include, but are not limited to, the following:

i) Site Planning-orientation of buildings and outdoor recreational areas with respect to noise sources, spatial separation such as insertion of sound-insensitive land uses between source and receiver and appropriate setbacks; and

ii) Acoustical Barriers-berms, walls, favourable topographical features, other intervening structures.

GUIDELINES

Land Use Planning Principles

Planning principles should be adopted that minimize the chances of creating noise problem areas. Put simply, it means a proper place for every land use so that each use is compatible with the surroundings.

The overall goal should be to reduce the amount of residential land adversely affected by freeway noise. Residential areas should normally be located away from freeways. Wherever possible, commercial, light industrial, recreational and agricultural uses should buffer residential areas from noisy freeway traffic. If a residential area must be located near a freeway, suitably-designed medium and high density residential buildings are more adaptable to the noise environment than low density single-family units. Also, they perform the function of the noise barrier (barrier block) for the rest of a residential site.

Official Plans and Amendments

(a) If an official plan, relevant amendment, or secondary plan is under preparation, a municipality should consult with the Ministry of the Environment regarding appropriate noise control statements to be included in the plan.

(b) When an official plan or relevant amendment is submitted to the Region or the Ministry of Housing for approval, the provincial policy on Noise and New Residential Development Adjacent to Freeways will be included in the plan or amendment by modification if the municipality has not already done so.

Plans of Subdivision

(a) Prior to making a subdivision application, a developer should obtain information on the necessary actions to be taken from the Region or the Ministry of Housing. At this stage, a developer may be instructed to consult the Ministry of the Environment and the Ministry of Transportation and Communications.

(b) When the plan of subdivision is submitted to the Region or the Ministry of Housing for approval, the Region or the Ministry of Housing will ensure that the subdivision conforms to the provincial policy by circulating the plan of subdivision to the Ministry of the Environment and the Ministry of Transportation and Communications for comments and technical advice on noise control measures.

(c) The Region or the Ministry of Housing, upon weighing this advice against other technical, administrative and economic considerations, may then give draft approval with appropriate conditions. The implementation of the conditions will be achieved through a subdivision or development agreement.

Zoning Bylaw Amendments

(a) Since site planning is a major noise control measure, municipalities should use Section 35a of *The Planning Act* to implement appropriate conditions. (Ministry of Housing Guidelines for Development Control (Site Plan Control) — The Planning Act:

Section 35a February 1975) Publications on noise control measures are available from the Ministry of the Environment.

(b) Before passing a zoning bylaw amendment for a development affected by freeway noise, a municipality should refer the amendment to the Ministry of the Environment for comments.

(c) If the municipality passes such a bylaw without having regard to the provincial policy, the Region, the ministries of Housing, the Environment and, if a provincial freeway is involved, the Ministry of Transportation and Communications, will have to determine whether or not a potential noise problem exists and, if necessary, may object to the Ontario Municipal Board.

Special Information Required

The information required for review and evaluation of proposals for new residential development should include the following:

(a) Location of freeways — The plans should indicate the existing or planned future location of freeways within one kilometre.

(b) Site plan — The site plan should show the topography of the site, elevation and layout of the various existing buildings or proposed structures.

(c) Establishing the noise levels on site — The noise levels anticipated on the site should be established by the use of prediction techniques acceptable to the region and the Ministry of the Environment based, when necessary, on actual measurements. In all cases, consideration should be given to anticipated future increases in noise levels for at least ten years.

Current traffic information and traffic predictions for any particular provincial freeway may be obtained from the Ministry of Transportation and Communications.

Developers may obtain further information on traffic noise prediction techniques from the most up-to-date government publications, from acoustical literature, and from the Noise Pollution Control Section of the Ministry of the Environment, Toronto.

6.3 Suggested Format for a Noise Study

These guidelines offer some suggestions regarding presentation of noise impact studies for subdivision approval for consideration by the Municipality and the Ministry of the Environment. Data presented in this format reduces the time it takes to review the reports.

1. The report should be predicated on the planning objectives of the area as obtained from the municipality.

2. The report should organize the information in frequent headings and small paragraphs.

3. The main text should contain the following information.

   (i) A brief description of the noise-climate at the site, listing the various significant noise sources of concern. Approximate distances and mode of operations of sources should also be given.

   (ii) Noise levels at the site due to the individual sources should be summarized preferably in a tabular form.

   (iii) Combined noise levels at the site due to all noise sources should be listed for representative locations.

   (iv) A comparison should be presented between the projected noise levels and the Provincial sound level policies and guidelines so that excess noise levels may be readily apparent.

(v) The locations and the dimensions of the noise control measures to eliminate any excess over the Provincial Levels should be presented.

f the report is a *feasibility study* leading to draft pproval of the subdivision it would suffice to indicate he approximate locations, and the general nature of the ndoor and outdoor noise control measures. An example s printed below:

> "The noise levels in the exposed outdoor areas of the first two rows of houses would be approximately 63 dBA (24 hour Leq) due to the traffic activity on Highway 101. To reduce these levels to 55 dBA (MOE outdoor sound level limit guidelines) the developer has proposed to place the designated outdoor recreational areas on the shielded side of the houses. In addition, a forced air ducted heating system modified to allow for easy installation of a central air conditioning unit or some other form of positive ventilation system will be provided. Standard, double glazed windows as permitted by the building code will be provided to meet the MOE indoor sound level limits."

If, on the other hand, the report is prepared to clear the conditions of draft approval, and leading to the registration of the subdivision plan, the control measures should be detailed. Note that these control measures will be entered into the Subdivision Agreement or the Engineering Agreement. They should be detailed enough to be checked by the building inspector during construction. An example follows:

> "For housing units directly exposed to the Highway 101, forced air-ventilation type of heating system should be installed with a provision to readily accept air-conditioning at a future date.
>
> Further, double glazed windows be provided for all *exposed* windows for these units. Lots and blocks so affected include:
>
> Lots A, B, C,
>
> The recreational areas and yards of the lots directly exposed to the Highway 101 be shielded by erecting noise screens.
>
> The arrangement of noise screens in relation to recreational spaces and yards is shown in the attached sketch. The lots affected include:
>
> Eight foot noise screens for lots D, E, F, and six foot high noise screens for lots G, H, I."

APPENDICES TO THE REPORT

The following information should be presented in an appendix to the main text.

i) Projected traffic data for 10 years hence; also report the source of the data.

ii) Any measurements including type of instrumentation, duration, etc.

iii) Calculations for noise level prediction, barrier heights, etc.

iv) An illustration of proposed mitigation measures.

v) An estimate of costs involved in implementing proposed solution.

6.4 Canada Mortgage and Housing Corporation (C.M.H.C.) Noise Levels

ROAD AND RAIL TRAFFIC NOISE

The levels itemized below reflect the maximum levels which are acceptable to CMHC. If these levels are exceeded the project will be denied financing under the *National Housing Act*.

Maximum acceptable levels of road and rail traffic noise in dwelling and in outdoor recreation areas are listed below:

	Noise Level
Bedrooms	35 dB
Living, dining, recreation rooms	40 dB
Kitchens, bathrooms, hallways, utility rooms	45 dB
Outdoor recreation areas	55 dB

In an ordinary dwelling complying with "Residential Standards" the indoor noise level should be at least 20 dB below the outdoor level when windows are closed. If the outdoor noise level is no more than 55 dB, then all the proposed requirements could normally be met by construction complying with "Residential Standards" although it might still be prudent to locate bedrooms on the quieter side of the building.

These noise levels are based on models that account for road and rail traffic volumes over a 24 hour period.

AIRPORT NOISE

CMHC has identified various zones, based on NEF contours, adjacent to airports. These are:

a) an upper zone — where NEF values are greater than 35.

b) an intermediate zone — where NEF values are between 30 and 35 inclusive.

c) a lower zone — where NEF values are between 25 and 30.

The following policies have been developed by CMHC with respect to financing housing in these zones.

a) in the upper zone, housing shall be denied financing under the *National Housing Act*;

b) in the intermediate zone, housing shall be denied financing under the *National Housing Act* unless adequate sound insulation is provided; and

c) in the lower zone, the provision of adequate sound insulation is recommended. Housing shall be denied financing under the *National Housing Act* in the upper third of this zone, i.e. between 28 and 30 NEF, when the sound insulation proposed is substantially below that considered to be adequate.

6.5 Annotated Bibliography

6.5.1 Publications Dealing with Noise

1. "ACOUSTICS TECHNOLOGY IN LAND USE PLANNING", Volume 1, Analysis of Noise Impact, Ministry of the Environment, Ontario, November 1978.

This training manual was prepared to complement land use assessment under the provisions of *The Planning Act*. The planning process in Ontario is discussed including the Ministry's role.

The manual provides a background to acoustics including the nature and behaviour of sound waves, sound pressure and power levels. To measure the variability of community noise the concept of L_N and energy equivalent continuous level (Leq) is introduced. These noise descriptors are applied to understanding how, when and where the limits set forth in the Model Municipal Noise Control By-Law are used.

In the field of acoustic and land use planning, prediction models are required to determine the noise impact from roads and railways. Procedures and worked examples are included to allow prediction of rail and road noise.

Evaluation of noise in the vicinity of airports is based on the Noise Exposure Forecast (NEF) System.

The manual outlines various measures which can be taken to lower indoor and outdoor noise levels to acceptable limits, including, site planning, barrier, architectural design, and construction techniques. Methods are provided to calculate barrier heights and insulation requirements.

The manual includes a section on measurement of sound with a sound level meter including operation of the meter, calibration and proper measurement techniques.

2. "ACOUSTICS TECHNOLOGY IN LAND USE PLANNING", Volume 2, Road Traffic Noise Tables, Ministry of the Environment, Ontario, July 1977.

This training manual was prepared to complement land use assessment under the procedures discussed in Volume 1. To aid in the prediction of road traffic noise adjacent to residential development the manual provides two different sets of Tables, procedures for their use, limitations on their use and worked examples. The first set of Tables can be used to "red flag" those land areas subjected to a significant noise impact. The second set of Tables indicate the desirable forms of noise control measures which should be considered to reduce the sound levels in "red flagged" areas down to acceptable values.

A discussion is included on the application of noise control measures such as site planning, acoustical barriers, architectural design and construction techniques, as well as the theoretical background to the traffic noise level prediction model and publication NPC-131 of the Model Municipal Noise Control By-law, Guidelines for Noise Control in Land Use Planning.

3. "DESIGN PRINCIPLES FOR HIGHWAY NOISE BARRIERS", Research and Development Division, Ministry of Transportation and Communications, Ontario, November 1975.

This report provides sufficient theory and practice of noise barrier design to enable planners and designers to estimate the attenuation of barriers in relatively simple topographic situations, evaluate and rate different barrier material, understand the acoustic effects of holes, slits and gaps, and to realize the situations where prediction methods are ineffective.

4. "INFORMATION ON LEVELS OF ENVIRONMENTAL NOISE REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY", U.S. Environmental Protection Agency, Washington, D.C., March 1974.

The requirement of this document was to publish "information" as to the levels of noise "requisite to protect the public health and welfare with an adequate margin of safety". In addition to direct disease-producing health effects, interference by noise with various human activities, such as speech-perception, sleep and thought can lead to annoyance and indirect effects on well-being. All of these direct and indirect effects are considered within this document. Levels are classified for interference and hearing loss according to primary activities that are most likely to occur in areas such as residential, commercial, industrial, etc.

Discussions are included within the appendices on equivalent sound levels and its relationship to other noise measures, levels of environmental noise in the U.S. and typical exposure patterns of individuals, noise-induced hearing loss, noise interference with human activities and resulting overall annoyance/health effects, general effects of noise not directly used in identifying levels of noise requisite to protect public health and welfare, EPA's responsibility to identify safe levels for occupational noise exposure, impulsive and other special noises.

5. "MODEL MUNICIPAL NOISE CONTROL BY-LAW", Final Report, Ministry of the Environment, Ontario, August 1978.

This document presents a Model Municipal Noise Control By-law in two formats.

The Model Municipal Noise Control By-law Part I is a simple qualitative (subjective) By-law likely to be suitable for smaller municipalities with less complex noise problems. The Model Municipal Noise Control By-law Part II, is a comprehensive by-law with both qualitative and quantitative portions from which a municipality may select suitable sections according to its needs. Guidelines on land use planning procedures form an integral part of the document.

6. "NEW HOUSING AND AIRPORT NOISE", Central (Canada) Mortgage and Housing Corporation, March 1978.

This publication defines areas near airports where the Corporation will make financing available under the *National Housing Act*. In some areas, the availability of financing will depend upon the inclusion of adequate sound insulation in dwelling units.

The evaluation of the noise problems near airports associated with flyover and ground sources is expressed in terms of the Noise Exposure Forecast (NEF). Included within the publication is a description of this forecast, a classification of areas adjacent to airports and the Corporation policy towards financing near airports.

In some instances the provision for adequate sound insulation in new buildings is required. A method is provided for selecting appropriate building components which provide adequate sound insulation based on an Acoustic Insulation Factor (AIF).

7. "ONTARIO HIGHWAY NOISE PREDICTION METHOD", RR 197, Research and Development Division, Ministry of Transportation and Communications, Ontario, January 1975.

This report describes the development, accuracy, reliability and application of the Ontario Highway Noise Prediction Method. It is an empirical method based on 133 sound level measurements taken at 120 locations near rural and urban freeways, highways and along residential streets. The Ontario method is compared with both the Bolt Beranek Newman and Delany highway noise prediction methods.

The report outlines the construction and the statistical evaluation of mathematical models which form the basis of the Ontario method. The proposed Ontario method enables calculation of L_{50} and L_5 sound levels with a higher level of accuracy than other methods evaluated.

A detailed description of the observations used for the development of the Ontario Highway Noise Prediction Method and a step-by-step procedure for the application of the method are provided within the appendices.

8. "AN LEQ PREDICTION METHOD, A BRIEF OUTLINE", Systems Research and Development Branch, Ministry of Transportation and Communications, Ontario, June 1976.

This paper outlines the development, accuracy, reliability and application of a method for the prediction of Leq levels due to traffic noise. The original Ontario Highway noise prediction method predicted L_5, L_{10}, and L_{50} sound levels based on an empirical method using 133 field noise measurements. The Leq prediction method uses these measurements plus 55 additional measurements. The mathematical model related Leq sound levels to independent variables such as vehicular volumes, speed and distance. Use of the model is facilitated by a nomograph.

The basic step-by-step procedure for prediction of Leq levels is not given as it is the same as the procedure for the prediction of L_{10} levels with the exceptions noted within the paper.

9. "ROAD AND RAIL NOISE: EFFECTS ON HOUSING", Central (Canada) Mortgage and Housing Corporation, December 1977.

This document was prepared to suggest methods of determining the noise level at a building/site and where levels are too high, reducing them to acceptable limits within the various parts of the building where the noise occurs.

Availability of NHA financing with respect to noise levels is discussed and in some instances the inclusion of noise reduction measures may be required.

The document outlines the traffic and rail noise problems, acceptable levels of noise, classification of adjacent areas, procedures for estimating outdoor noise levels both with and without barrier attenuation and a set of worked examples which illustrate the procedures.

In some instances, the provision for adequate sound insulation in new buildings is required. A method is provided for selecting appropriate building components which provide adequate sound insulation based on an Acoustic Insulation Factor (AIF).

6.5.2 Publications Dealing with the Comprehensive Issue of Site Planning

1. "SITE PLANNING, SECOND EDITION", Kevin Lynch, M.I.T. Press, 1971.

The art of site planning is comprehensively covered by chapters on analyzing a locality, organizing place and action, movement systems, problems of control and design and management of the site. These are interspersed by technical chapters on site form and ecology, social and phychological analyses, streets and ways, earthwork and utilities, design methods, and costs.

Discussions of housing and special types of site planning (shopping centres and commercial strips, industrial districts, institutions, open space, and renewal) conclude the book.

2. "SITE PLANNING CRITERIA", Central (Canada) Mortgage and Housing Corporation, 1977.

This document was prepared to form the basis for the review of site planning for housing financed under the terms of the *National Housing Act*.

The document provides criteria for the location of housing, site development, housing on conventional lots, and comprehensively planned housing. The criteria list the basic requirements on the use and design of space to give a minimum quality of housing.

Conformity with the criteria is a prior condition for an NHA loan, although the amount depends upon CMHC's assessment of the overall quality of individual projects.

3. "MANUAL FOR THE DESIGN AND CONTROL OF LAND DEVELOPMENT IN SUBURBAN COMMUNITIES", The Institute of Rational Design, New York, 1976.

This manual is a case study illustrating the development of a plan for suburban housing in the periphery of an existing city. It contains a discussion of the problems created by suburban housing and the pressures it places upon local governments. The case study documents step-by-step, the analyses, planning and design studies for an actual project located in suburban Orange County, New York.

4. "LAND DEVELOPMENT MANUAL", National Association of Home Builders, Washington, D.C., 1974.

This manual is the complete entrepeneur's guide to the planning, construction and marketing of housing.

The book contains chapters on the design of single family dwellings, townhouses, and apartments. A substantial amount of information on landscaping, grading and public utilities is also included.

5. "SITE PLANNING GUIDELINES FOR MEDIUM DENSITY HOUSING", Local Planning Policy Branch, Ministry of Housing, January 1980.

This report was prepared by a team of consultants headed by Henry Fliess and Partners, Architects. The guidelines are designed to aid small and medium sized municipalities in evaluating medium density housing developments.

The report covers all aspects of site planning for medium density housing which is defined as being

between 22 units per hectare (9 units per acre) and 90 units per hectare (36 units per acre). The guidelines demonstrate that well planned, medium density housing can provide much of the same amenities and environment as single detached housing. Equally important, the guidelines emphasize that such housing is energy and land efficient and responsive to emerging demographic trends which indicate that the rate of family formation is falling.

6. "URBAN PLANNING AND DESIGN CRITERIA, 2nd edition" Joseph De Chiara and Lee Koppelman, Van Nostrand Reinhold, 1975.

This volume provides in a single source many of the generally accepted concepts and standards required for physical and urban planning. An extensive amount of practical information is included.

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